SERVICE MANUAL

DIGITAL MULTIMETER

3468A

HEWLETT PACKARD

hp 3468A

HEWLETT PACKARD

SERVICE MANUAL

MODEL 3468A DIGITAL MULTIMETER

Serial Numbers: 2137A00101 and Greater

IMPORTANT NOTICE

If the Serial Number of your instrument is lower than the one on this Title Page, the manual contains revision that do not apply to your instrument. Backdating information given in the manual adapts it to earlier instruments.

Where practical, backdating information is integrated into the text, parts list and schematic diagrams. Backdating changes are denoted by a delta sign. An open delta (Δ) or lettered delta (Δ_A) on a given page, refers to the corresponding backdating note on that page. Backdating changes not integrated into the manual are denoted by a numbered delta (Δ_1) which refers to the corresponding change in the Backdating Section (Section VI).

WARNING

To help minimize the possibility of electrical fire or shock hazards, do not expose this instrument to rain or excessive moisture.

The information in this manual is for the use of Service Trained Personnel. To avoid shock, do not perform any procedures in the manual or do any servicing to the 3468A unless you are qualified to do so.

Manual Part No. 03468-90004

Microfiche Part No. 03468-90054

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Installation
and Operation

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and Calibration

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CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Bureau of Standards, to the extent allowed by the Bureau's calibration facility, and to the calibration facilities of other International Standards Organization members.

WARRANTY

This Hewlett-Packard product is warranted against defects in material and workmanship for a period of one year from date of shipment [,except that in the case of certain components listed in Section I of this manual, the warranty shall be for the specified period] . During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by -hp-. Buyer shall prepay shipping charges to -hp- and -hp- shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to -hp- from another country.

Hewlett-Packard warrants that its software and firmware designated by -hp- for use with an instrument will execute its programming instructions when properly installed on that instrument. Hewlett-Packard does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HEWLETT-PACKARD SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HEWLETT-PACKARD SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

ASSISTANCE

Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

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SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements. This is a Safety Class 1 instrument.

GROUND THE INSTRUMENT

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument is equipped with a three-conductor ac power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact to two-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet International Electrotechnical Commission (IEC) safety standards.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

DANGEROUS PROCEDURE WARNINGS

Warnings, such as the example below, precede potentially dangerous procedures throughout this manual. Instructions contained in the warnings must be followed.

WARNING

Dangerous voltages, capable of causing death, are present in this instrument. Use extreme caution when handling, testing, and adjusting.

SAFETY SYMBOLS

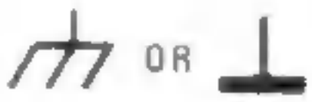
General Definitions of Safety Symbols Used On Equipment or In Manuals.

Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect against damage to the instrument.

Indicates dangerous voltage (terminals fed from the interior by voltage exceeding 1000 volts must be so marked).

Protective conductor terminal. For protection against electrical shock in case of a fault. Used with field wiring terminals to indicate the terminal which must be connected to ground before operating equipment.

Low-noise or noiseless, clean ground (earth) terminal. Used for a signal common, as well as providing protection against electrical shock in case of a fault. A terminal marked with this symbol must be connected to ground in the manner described in the installation (operating) manual, and before operating the equipment.



Frame or chassis terminal. A connection to the frame (chassis) of the equipment which normally includes all exposed metal structures.

Alternating current (power line).

Direct current (power line).

Alternating or direct current (power line).

WARNING

The WARNING sign denotes a hazard. It calls attention to a procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in injury or death to personnel.

CAUTION

The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, condition or the like, which,if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product.

NOTE:

The NOTE sign denotes important information. It calls attention to procedure, practice, condition or the like, which is essential to highlight.

SECTION I
GENERAL INFORMATION

WARNING

The information in this manual is for the use of Service Trained Personnel. To avoid electrical shock, do not perform any procedures in the manual or do any servicing to the 3468A unless you are qualified to do so.

1-1. INTRODUCTION

1-2. The information in this manual is for the Installation, Operation, Performance, Calibration, and Service of the 3468A Digital Multimeter. The manual is designed for the use of Service Trained Personnel. Other users should refer to the Operators Manual. This manual is separated into the following sections.

1-3. Section I, General Information

1-4. A short description of the manual and introduction to the 3468A is in Section I. The section also lists instrument specifications and accessories.

1-5. Section II, Installation Procedures

1-6. This section explains how the 3468A is prepared for use and includes power requirements, line voltage selection, etc. The section also explains how to connect the multimeter for remote operation.

1-7. Section III, Operation

1-8. The condensed operating instructions of the 3468A, for the use of Service trained Personnel, is in this section. For more complete instructions, refer to the Operators Manual.

1-9. Section IV, Performance Test and Calibration

1-10. The 3468A's Performance Test and Calibration Procedures are in Section IV. The Required Equipment Table and an abbreviated specification table are also included.

1-11. Section V, Replaceable Parts

1-12. Section V lists the replaceable parts of the 3468A. It also includes pictures and illustrations of chassis and mechanical parts.

1-13. Section VI, Backdating

1-14. This section has information for adapting the manual to 3468A's with serial numbers below the ones shown on the title page.

1-15. Section VII, Service

1-16. The 3468A's Troubleshooting Procedures, Theory Of Operation, and Schematics are in Section VII. The troubleshooting information is in the form of Service Groups which are symptoms oriented (i.e., what is the failure). The complete theory of operation is in Service Group F and the Schematics are in Service Group G (last group).

1-17. Appendix A

1-18. The appendix has a condensed description of the HP-IL (Hewlett-Packard Interface Loop).

1-19. DESCRIPTION

1-20. The -hp- Model 3468A is a versatile multimeter with dc and ac volts, dc and ac current, and resistance measurement capabilities. The multimeter is excellent for bench use, and since it is remotely programmable, it can be used in measurement systems. A feature of the instrument is that the reading can be displayed in either 5 1/2, 4 1/2, or 3 1/2 digits. Other features are Autozero (for good stability), and an AlphaNumeric Liquid Crystal Display.

1-21. Another excellent feature is Electronic Calibration. No mechanical adjustments are necessary to calibrate the 3468A.

1-22. SPECIFICATIONS

1-23. Specifications of the 3468A are the performance characteristics of the multimeter which are certified. The specifications are listed in Table 1-1 and Table 4-1 (in Section IV). They are the performance standards or limits against which the multimeter can be tested.

1-24. INSTRUMENT AND MANUAL IDENTIFICATION

1-25. Instrument Identification is by a serial number located on the multimeter's rear panel. Hewlett-Packard uses a two-part serial number with the first part (prefix) identifying a series of instruments and the second part (suffix) identifies a particular instrument within a series. An -hp- assigned alpha character between the prefix and suffix identifies the country in which the 3468A was manufactured.

Table 1-1. Specifications

DC VOLTAGE

Input Characteristics:

Range	Maximum Reading (5½ Digit)	Resolution 5½ Digit	4½ Digit	3½ Digit
.3V	±.301000V	1μV	10μV	100μV
3V	±3.01000V	10μV	100μV	1mV
30V	±30.1000V	100μV	1mV	10mV
300V	±301.000V	1mV	10mV	100mV

Input Resistance:

.3V, 3V ranges: $>10^{10}\Omega$
30V, 300V ranges: 10MΩ ± 1%

Maximum Input Voltage: (non-destructive)

Hi to Lo: 301 Vrms or 450V peak
Hi or Lo to Earth Ground: ±500V peak

Measurement Accuracy:

±(% of reading + number of counts)
Auto-zero ON

5½ Digit Mode:

Range	Cal. Temp ± 1°C 24 Hours	Cal. Temp. ±5°C 90 Day	1 Year
.3V	0.005 + 4	0.009 + 5	0.02 + 5
3V	0.0035 + 2	0.007 + 2	0.018 + 2
30V	0.005 + 3	0.009 + 3	0.02 + 3
300V	0.0055 + 2	0.009 + 2	0.02 + 2

4½ and 3½ Digit Mode:

Accuracy is the same as 5½ digit mode for % of reading, use 1 count for number of counts.

The Cal. Temp. (Calibration Temperature) is the temperature of the environment where the 3468A was calibrated. Calibration should be performed with the temperature of the environment between 20°C and 30°C.

Auto-Zero Off:

(5½ digit) for a stable environment (±1°C), for <24 hrs., add 11 counts to accuracy specification for .3V and 30V ranges, 3 counts for 3V and 300V ranges. For 4½ or 3½ digits, multiply counts by 0.1.

Temperature Coefficient:

0°C to (Cal. Temp. −5°C),(Cal. Temp. +5°C) to 55°C
5½ digit display, auto-zero ON
± (% of reading + number of counts)/°C

Range	Temperature Coefficient
.3V, 30V	0.0008 + .5
3V, 300V	0.0007 + .05

Noise Rejection:

In dB, with 1kΩ imbalance in Lo lead. AC rejection for 50, 60Hz ± 0.1%. Auto-zero ON.

Display	AC NMR	AC ECMR	DC CMR
5½ digits	80	150	140
4½ digits	59	130	140
3½ digits	0	70	140

Maximum Reading Rates: (readings/sec)

First reading is correct within .1 count of final value, when on correct range, triggered coincident with step input.

The reading rates are dependent on the speed of the controller being used.

Line Frequency	Auto Zero	Resolution 3½ Digits	4½ Digits	5½ Digits
60Hz	Off	32	21	3.7
	On	25	13.4	2
50Hz	Off	32	19	3.1
	On	25	.12	1.7

Maximum Reading Rate with 41CV:

2 readings/sec

Display Rate: (readings/sec)

For 50 or 60 Hz operation.

	5½ Digits	4½ or 3½ Digits
Auto Zero off	4	4
Auto Zero On	2	4

Resistance (2-wire Ω, 4-wire Ω)

Input Characteristics:

Range	Maximum Reading (5½ Digit)	Resolution 5½ Digit	4½ Digit	3½ Digit
300 Ω	301.000 Ω	1mΩ	10mΩ	100mΩ
3 kΩ	3.01000 kΩ	10mΩ	100mΩ	1 Ω
30 kΩ	30.1000 kΩ	100mΩ	1 Ω	10 Ω
300 kΩ	301.000 kΩ	1 Ω	10 Ω	100 Ω
3MΩ	3.01000MΩ	10 Ω	100 Ω	1 kΩ
30MΩ	30.1000MΩ	100 Ω	1 kΩ	10 kΩ

Input Protection: (non-destructive)

Hi source to Lo source: ±350V peak
Hi sense to Lo sense: ±350V peak
Hi or Lo to Earth Ground: ±500V peak

Measurement Accuracy:

±(% of reading + number of counts)
Auto-zero ON. 4-wire ohms.

Table 1-1. Specifications (Cont'd)

Resistance (2-wire Ω, 4-wire Ω) (Cont'd)

5½ Digit

Range	Cal. Temp ± 1°C 24 Hours	Cal. Temp. ±5°C Day	Cal. Temp. ±5°C 1 Year
300Ω	0.0045 + 4	0.012 + 5	0.017 + 5
3k – 300kΩ	0.0035 + 2	0.011 + 2	0.016 + 2
3MΩ	0.0052 + 2	0.011 + 2	0.016 + 2
30MΩ	0.036 + 2	0.066 + 2	0.078 + 2

2-Wire Ohms Accuracy:

Same as 4-wire ohms, except add a maximum of 100mΩ offset.

Auto-Zero Off:

(5½ digit) for a stable environment (±1°C), for <24 hrs., add 11 counts to accuracy specification for 300Ω range 3 counts for 3kΩ through 300kΩ ranges, counts for 3MΩ range, and 33 counts for 30MΩ range.

Temperature Coefficient:

0°C to (Cal. Temp. – 5°C),(Cal. Temp. + 5°C) to 55°C
5½ digit display, auto-zero ON
± (% of reading + number of counts)/°C

Range	Temperature Coefficient
300Ω	0.0009 + 0.5
3k – 300kΩ	0.0009 + 0.05
3MΩ	0.0021 + 0.05
30MΩ	0.021 + 0.05

Current Through Unknown:

Range:	300Ω	3kΩ	30kΩ	300kΩ	3MΩ	30MΩ
Current:	1mA	1mA	100μA	10μ	1μ	100nA

Maximum Open Circuit Voltage:

6.5V

Maximum Reading Rates:

Same as dc volts, except for 3MΩ and 30MΩ ranges. For 3MΩ range, add 20ms; for 30MΩ range, add 200ms per reading.

AC VOLTAGE (true rms responding)

Input Characteristics:

Range	Maximum Reading (5½ Digit)	Resolution 5½ Digit	Resolution 4½ Digit	Resolution 3½ Digit
.3V	.301000V	1μV	10μV	100μV
3V	3.01000V	10μV	100μV	1mV
30V	30.1000V	100μV	1mV	10mV
300V	301.000V	1mV	10mV	100mV

Input Impedance:

1MΩ ± 1% shunted by <60pF

Maximum Input Voltage: (non-destructive)

Hi to Lo: 301Vrms or 450V peak
Hi or Lo to Earth Ground: ±500V peak

Measurement Accuracy:

±(% of reading + number of counts)
Auto-zero ON. 5½ digit display. Accuracy is specified for sine-wave inputs only, >10% of full scale.
1 Year, Cal. Temp. ±5°C

Frequency	.3V	Ranges 3V, 30V	300V
20Hz-50Hz	1.14 + 163	1.14 + 102	1.18 + 102
50Hz – 100Hz	0.46 + 163	0.46 + 103	0.5 + 102
100Hz – 20kHz	0.29 + 163	0.26 + 102	0.33 + 102
20kHz – 50kHz	0.56 + 247	0.41 + 180	0.55 + 180
50kHz – 100kHz	1.74 + 882	1.05 + 825	1.26 + 825
100kHz – 300kHz		10.1 + 3720 (30V range only)	

Auto-Zero Off:

(5½ digits) for a stable environment (±1°C), for <24 hrs., add 10 counts to accuracy specifications for all ranges.

Temperature Coefficient:

0°C to (Cal. Temp. – 5°C),(Cal. Temp. + 5°C) to 55°C,
5½ digit display, auto-zero ON.
For frequencies <20kHz, (0.016% of reading + 10 counts)/°C
For frequencies >20kHz, ±(0.04% of reading + 10 counts)/°C

Crest Factor:

>4:1 at full scale.

Common Mode Rejection:

With 1kΩ imbalance in Lo lead, >70dB, dc to 60Hz.

Maximum Reading Rates: (readings/sec)

First reading is correct within 70 counts of final value, when on correct range, triggered coincident with step input. Add 0.6 seconds for each range change.

For 50 or 60Hz operation, auto-zero ON or OFF.
3½ or 4½ digits: 1.4 readings/sec
5½ digits: 1.0 readings/sec

DC CURRENT

Input Characteristics:

Range	Maximum Reading (5½ Digit)	Resolution 5½ Digit	Resolution 4½ Digit	Resolution 3½ Digit
3A	±3.01000A	10μA	100μA	1mA

Maximum Input: (non-destructive)

3A from <250V source; fuse protected

Measurement Accuracy:

± (% of reading + number of counts)
Auto-zero ON. 5½ digit display.

Range	Cal. Temp. ±5°C 90 Days	Cal. Temp. ±5°C 1 Year
3A, <1A input	0.14 + 6	0.17 + 6
3A, >1A input	1.0 + 30	1.0 + 30

Table 1-1. Specifications (Cont'd)

DC CURRENT (Cont'd)

Auto-Zero Off:

(5½ digit) for a stable environment (± 1°C), for < 24 hrs., add 11 counts to accuracy specification for 5½ digit mode.

Temperature Coefficient:

0°C to (Cal. Temp. − 5°C),(Cal. Temp. + 5°C) to 55°C
5½ digit display, auto-zero ON
± (0.012 of reading + 0.5 counts)/°C

Maximum Burden ■ Full Scale:

1V

Maximum Reading Rates:

Same as dc volts

AC CURRENT (true rms responding)

Input Characteristics:

Range	Maximum Reading (5½ Digit)	Resolution 6½ Digit	Resolution 4½ Digit	Resolution 3½ Digit
.3A	.301000A	1μA	10μA	100μA
3A	3.01000A	10μA	100μA	1mA

Maximum Input: (non-destructive)

3A from < 250V source; fuse protected

Measurement Accuracy:

± (% of reading + number of counts)
Auto-zero ON. 5½ digit display. Accuracy specified for sine-wave inputs only > 10% of full scale.
1 YEAR, CAL. TEMP. ± 5°C

Frequency	Ranges 300mA	Ranges 3A
20Hz – 50Hz	1.77 + 163	2.5 + 163
50Hz – 1kHz	1.1 + 163	1.8 + 163
1kHz – 10kHz	1.0 + 163	1.7 + 163
10kHz – 20kHz	1.14 + 163	1.84 + 163

Auto-zero Off:

(5½ digits) for ■ stable environment (± 1°C), for < 24 hrs., add 10 counts to accuracy specification.

Temperature Coefficient:

0°C to (Cal. Temp. − 5°C), (Cal. Temp. + 5°C) to 55°C.
5½ digits, auto-zero ON.
± (0.021% of reading + 10 counts)/°C

Maximum Burden at Full Scale:

1V

Crest Factor:

> 4:1 at full scale

Maximum Reading Rates:

Same as ac volts

GENERAL INFORMATION

Operating Temperature:

0 to 55°C

Humidity Range:

95% R.H., 0 to 40°C

Storage Temperature:

− 40°C to 75°C
except for battery option, 40°C to + 65°C

Warm-up Time:

1 hr. to meet all specifications.

Integration Time:

Number of Digits	Line Frequency 50Hz	Line Frequency 60Hz
5½	200ms	166.7ms
4½	20ms	16.67ms
3½	2ms	2ms

Power:

AC Line 48 – 440Hz; 86 – 250V, (see configuration)

Battery: (Option 001)

Rechargeable lead-acid; minimum continuous operation for 5 hours at 25°C; recharge time is 16 hours with 3468A off and 36 hours with 3468A on.

Maximum Power:

< 13 VA

Size:

98.4mm H x 238.1mm W x 276.2mm D
(3.88 in H x 9.38 in W x 10.88 in D)

Weight:

3468A - 2.1 kg (4.63 lbs.)
3468A with Option 001 - 3.1 kg (6.83 lbs.)

1-26. This manual applies to instruments with the serial number identified on the title page. Updating of the manual is accomplished either by a change sheet or revised manual.

1-27. OPTIONS

1-28. The following options are available for the 3468A.

Option 001: add Rechargable Battery Pack
Option 315: set for 100V, 50Hz Power Source
Option 316: set for 100V, 60Hz Power Source
Option 325: set for 120V, 50Hz Power Source
Option 326: set for 120V, 60Hz Power Source
Option 335: set for 220V, 50Hz Power Source
Option 336: set for 220V, 60Hz Power Source
Option 345: set for 240V, 50Hz Power Source
Option 346: set for 240V, 60Hz Power Source
Option 910: additional set of Operators and Service Manuals

1-29. ACCESSORIES AVAILABLE

1-30. The following is a list of available accessories for the 3468A.

Accessory No.	Description
10023A	Temperature Probe
11000A	Test leads, dual banana both ends
11002A	Test leads, dual banana to dual alligator
11003A	Test leads, dual banana to probe and alligator
11096B	RF Probe
34111A	High Voltage Probe
34118A	Test Leads, dual banana to probes with safety guard rings
82167A	HP-IL Cable (2 each)

SECTION II
INSTALLATION

2-1. INTRODUCTION

2-2. This section of the manual has the necessary information and instructions to install and interface the -hp- Model 3468A Digital Multimeter. Included initial inspection procedures, power requirements, environmental information, and instructions for repacking the instrument for shipment. The information in this section is for Service Trained Personnel.

WARNING

The information in this manual is for the use of Service Trained Personnel. To avoid electrical shock, do not perform any procedures in this manual or do any servicing to the 3468A, unless you are qualified to do so.

2-3. INITIAL INSPECTION

2-4. The 3468A was carefully inspected both mechanically and electrically before shipment. It should be free of mars or scratches and in perfect electrical order upon receipt. The multimeter should be inspected for any damage that may have occurred in transit. If the shipping container or cushioning material is damaged, it should be kept until the contents of the shipment has been checked for completeness and the instrument has been mechanically and electrically checked. Procedures for checking the electrical performance of the 3468A are in Section IV. If there is mechanical damage, the contents are incomplete, or the multimeter does not pass its Performance Test, notify the nearest Hewlett-Packard Office (a list of the -hp- Sales/Service offices is located at the back of the manual). If the shipping container is damaged or the cushioning material shows signs of stress, notify the carrier as well as the Hewlett-Packard office. Save the shipping material for the carrier's inspection.

2-5. POWER REQUIREMENTS

2-6. The 3468A requires a power source of 100V, 120V, 220V, or 240V ac (-10%, +5%), 48Hz to 440Hz single phase. The maximum power consumption is 13VA. For the 3468A to meet its noise and normal mode rejection specifications, the multimeter must be operated using a line frequency of either 50Hz or 60Hz (dependent on option). A listing of the 3468A's power options, the corresponding power line voltage, and line frequency are follows:

Option	Voltage and Frequency
Option 315	100V ac @ 50Hz
Option 316	100V ac @ 60Hz
Option 325	120V ac @ 50Hz
Option 326	120V ac @ 60Hz
Option 335	220V ac @ 50Hz
Option 336	220V ac @ 60Hz
Option 345	240V ac @ 50Hz
Option 346	240V ac @ 60Hz

CAUTION

Before connecting power to the 3468A, make sure the power source matches the power requirements of the multimeter, as marked on the option label affixed to the rear panel. If the instrument is incompatable with the available power source, go to Paragraph 2-7 to reconfigure the multimeter.

2-7. Line Frequency and Line Voltage Selection

2-8. The Power Line Frequency can be selected from the switch behind the 3468A's rear panel. Locate the switch, shown in Figure 2-1, and set the switch to the desired power frequency (50Hz or 60Hz), as shown in the figure. To set the 3468A to the correct power line voltage, the instrument has to be first disassembled.

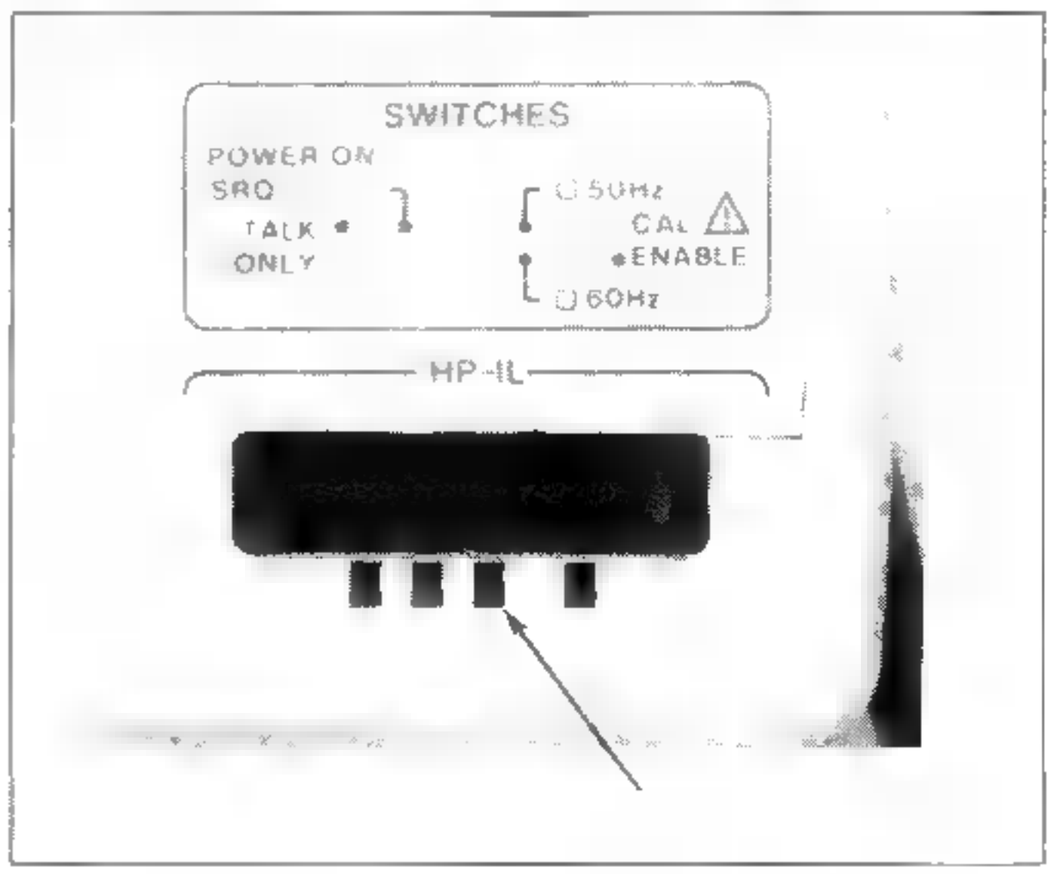


Figure 2-1. 3468A Power Frequency Switch

Then, make sure that the instrument is set to the correct power line voltage. If it is, reassemble the 3468A. If not, select the jumper for the correct voltage and then reassemble the instrument. The procedures to disassemble the 3468A, select the correct jumper, and reassemble the 3468A are in the following procedures.

WARNING

To avoid electrical shock and personal injury, make sure the multimeter is disconnected from its external power source before removing any covers.

a. Disassembly Procedure. Do the following:

1. Disconnect the 3468A's Power Cord and turn the instrument off.

2. With the multimeter in the inverted position, locate and loosen the four screws at the bottom of the instrument. (Loosen the screws only enough to remove the top cover.)

3. Carefully return the 3468A to the upright position with the front panel facing you.

CAUTION

The instrument contains CMOS Integrated Circuits which are susceptible to failure due to static discharge. It is especially important that grounded tools and wrist straps be used when handling printed circuit boards.

4. If the 3468A does not have the optional Battery Charger, lift the top cover up and away from the instrument and set it aside. Continue with step 6.

5. If the 3468A has the optional Battery Charger (Option 001), lift the top cover assembly up approximately one inch and then place it to the left of the instrument, in an inerted position as shown in Figure 2-2. Locate the battery supply cable and note that it is plugged into the instrument with the red stripe toward the outside of the instrument case. Carefully unplug the battery supply cable from the instrument.

6. Locate the power line select jumpers. They are located [redacted] the 3468A's main printed circuit board [redacted] the right side of the power transformer (see Figure 2-4). If the jumper is in the correct position, go to step c to reassemble the 3468A. If the jumper needs to be changed, continue with step b.

b. Power Line Jumper (J701) Selection. If the jumper has to be changed, the 3468A needs further disassembly. Do the following:

1. Refer to Figure 2-2 and locate the inner shield on the 3468A's main printed circuit board. Loosen and remove the mounting screw on the shield and then remove the shield, as shown in Figure 2-2.

2. Refer to Figure 2-3. Loosen and remove the printed circuit board mounting screws, as shown in the figure.

3. Remove the printed circuit board assembly by

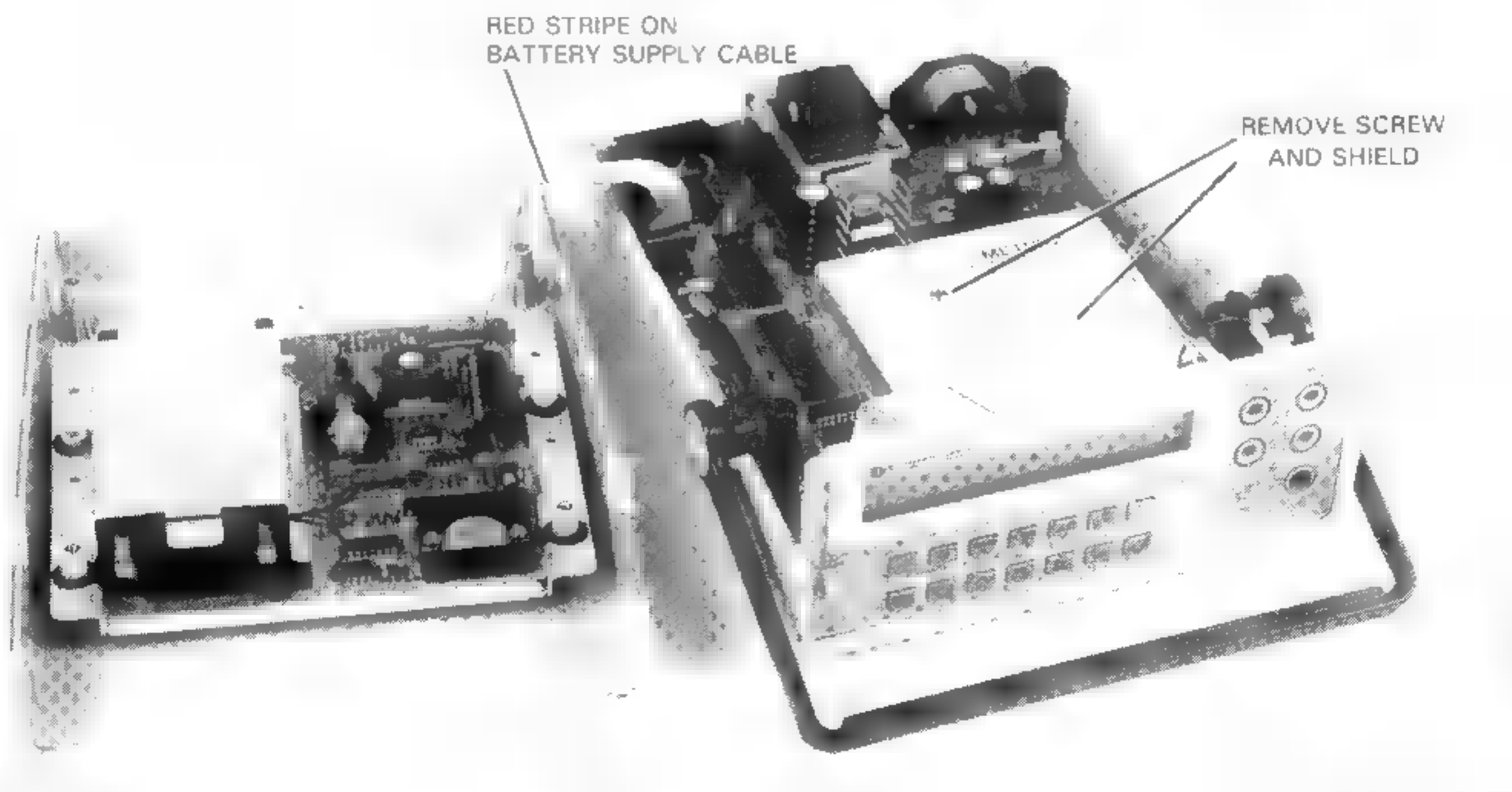


Figure 2-2. 3468A Top Cover Removed

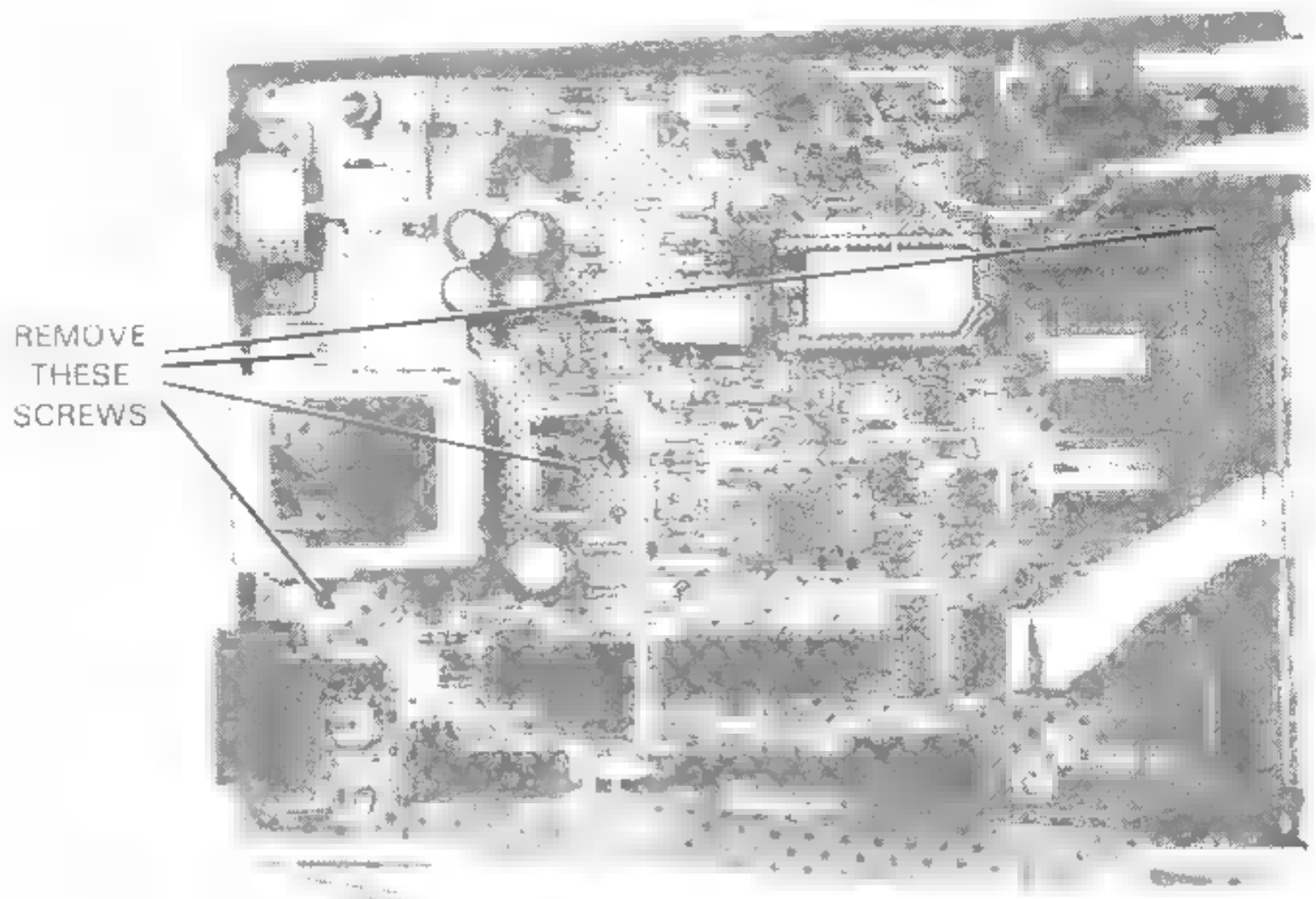


Figure 2-3. Top View with Inner Shield Removed

lifting it up and out of the 3468A's bottom assembly. Set the bottom assembly aside.

CAUTION

To prevent leakage paths on the main printed circuit board, hold and/or handle the board by the power transformer only.

4. Refer to Figure 2-4 and locate the power line jumper (J701).

5. Obtain a low wattage (25W) soldering iron. Unsolder and remove the power line jumper from the printed circuit board.

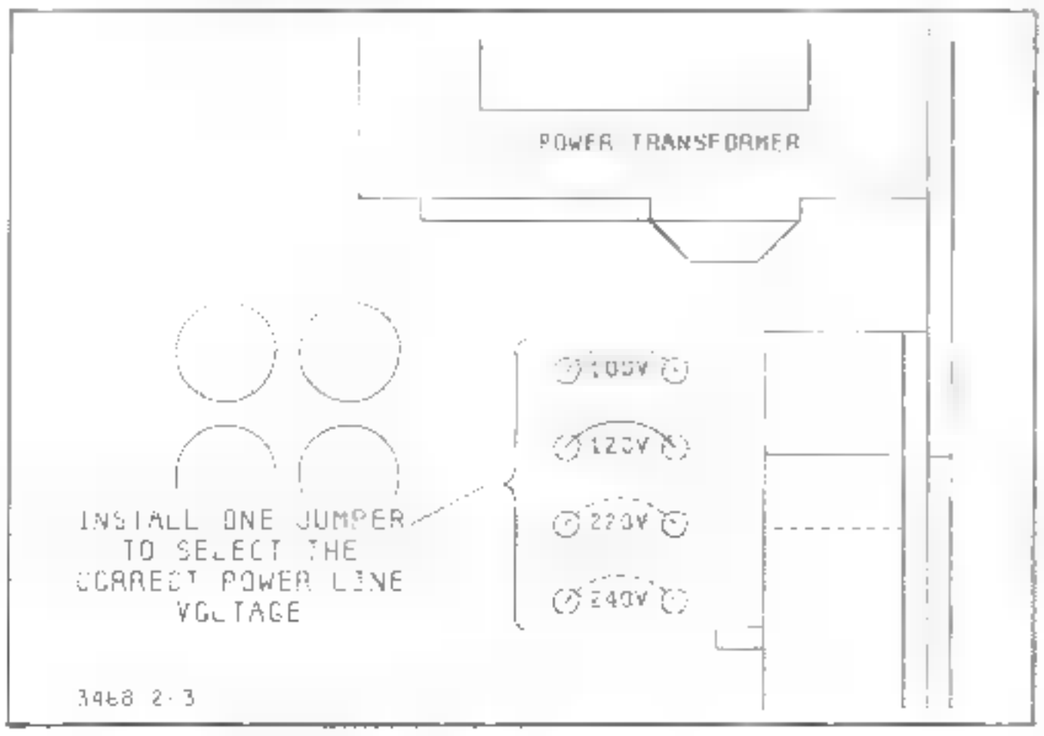


Figure 2-4. Power Line Voltage Configuration

6. Refer to Figure 2-4 and install jumper J701 into the holes for the desired power line voltage (the solder in the holes may have to be removed, before the jumper can be inserted into the holes). Make sure there is a good solder joint between the jumper and printed circuit board trace. The line voltages and corresponding jumper are as follows:

Jumper	Line Voltage
100	90V - 105V
120	108V - 126V
220	198V - 231V
240	216V - 252V

7. Once the jumper has been replaced, place the printed circuit board into the bottom assembly.

8. Reinstall the printed circuit mounting screws. Then reinstall the inner shield and the shield mounting screw.

c. Reassemble Procedure. Do the following:

1. If the optional Battery Charger is not installed, continue with step 4. If the Battery Charger is installed, continue with the next step.

2. Obtain the previously removed top cover assembly and set it next to the 3468A bottom assembly, as shown in Figure 2-2.

3. Locate the red stripe on the battery charger cable. Then plug the cable into the battery charger socket on the main printed circuit board with the red stripe facing away from the center of the instrument (i.e., facing to the left side of the 3468A). The cable has to be plugged in correctly, or the battery can be discharged and the power fuse may blow.

WARNING

Make sure the battery charger cable is in the correct position, or the battery can be discharged or the power fuse may blow.

4. Re-install the bottom assembly on the cover assembly insuring that the display, handle, and spacers fit properly into their respective locations. Also be sure that the battery supply cable does not interfere with a spacer.

5. If the power line voltage and/or line frequency was changed, re-mark the option label on the 3468A's rear panel to reflect those changes.

2-9. POWER CORDS AND RECEPTACLES

2-10. Figure 2-5 illustrates the different power plug configurations that are available to provide power to the 3468A. The -hp- part number shown directly below the individual power plug drawing is the part number for the power cord set equipped with the appropriate mating plug for that receptacle. If the appropriate power cord is not included with the instrument, notify the nearest -hp- Sales/Service office and a replacement will be provided.

2-11. HP-IL INTERFACE CONNECTIONS

2-12. The 3468A is compatible with the Hewlett-Packard Interface Loop. The interface connection is made by a pair of two-wire balanced line cables. The cable is limited to 10 meters (32.8 feet) for unshielded cables (from one device to the next) and to 100 meters (328 feet) for shielded cables. A typical interface connection is in Figure 2-6.

2-13. ENVIRONMENTAL REQUIREMENTS

WARNING

To prevent electrical fire or shock hazards, do not expose the instrument to rain or excessive moisture.

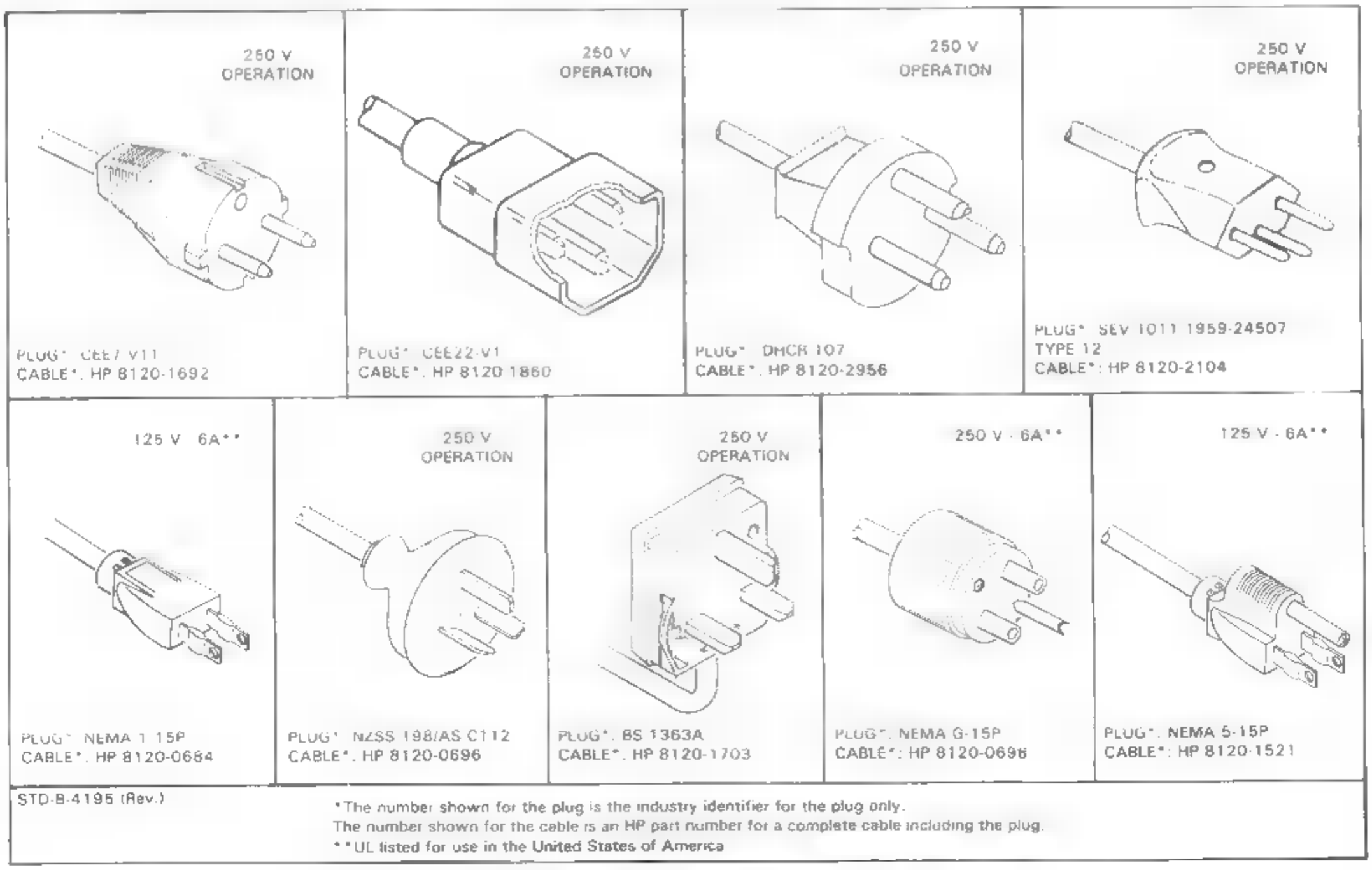


Figure 2-5. Power Cables

2-14. Operating and Storage Temperature

2-15. To meet and maintain the specifications listed in Table 1-1, the 3468A should be operated within ±5°C (±9°F) of the Reference Temperature. The Reference temperature is the temperature in which the 3468A was last calibrated. For example, if the last Reference Temperature was 23°C (73°F), the 3468A should maintain its specifications if operated within ±5°C (±9°F) of that temperature. The factory temperature is from 18°C to 28°C (64°F to 82°F). The 3468A may be operated within ▬ ambient temperature range of 0°C to 55°C (32°F to 131°F) with less accuracy.

2-16. REPACKAGING FOR SHIPMENT

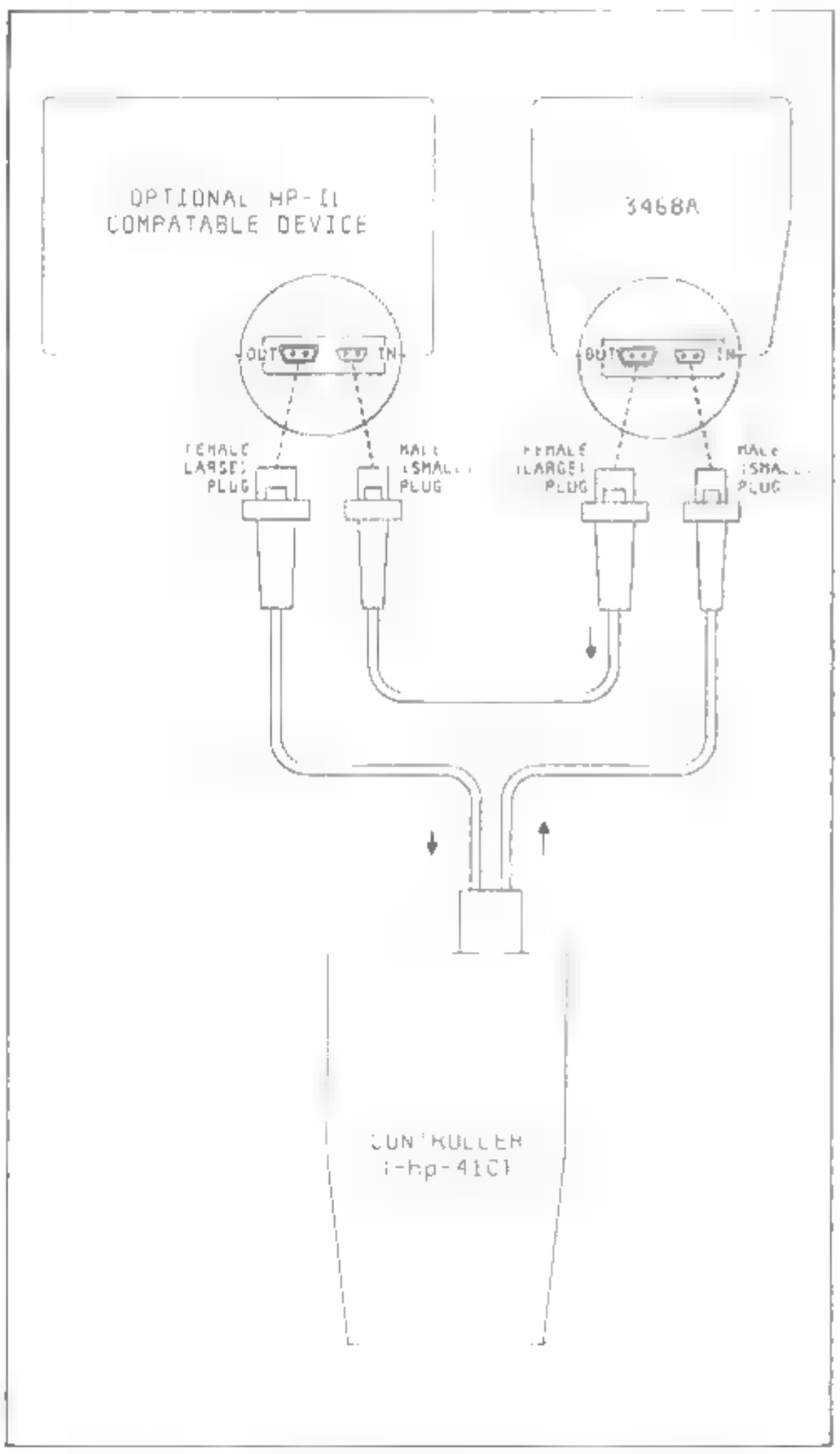


Figure 2-6. Typical HP-IL Interface Connection

NOTE

If the instrument is to be shipped to Hewlett-Packard for service or repair, attach a tag to the instrument identifying the owner and indicating the service or repair made. Include the model number and full serial number of the instrument. In any correspondence, identify the instrument by model number and full serial number. If you have any questions, contact your nearest -hp- Sales/Service office.

2-17. Place the instrument in its original container with appropriate packaging material and secure with strong tape or metal bands. If the original container is not available, ▬ replacement can be purchased from your nearest -hp- Sales/Service office. Hewlett-Packard suggests that you always insure shipments.

2-18. If the original container is not to be used, do the following:

a. Wrap the instrument in heavy plastic, before placing in an inner container.

b. Place packing material around all sides of the instrument and protect the front panel with cardboard strips.

c. Place the instrument in the inner container in a heavy carton. Seal the carton with strong tape or metal bands.

d. Mark shipping container "DELICATE INSTRUMENT", "FRAGILE", etc.

2-19. WHERE TO SHIP YOUR UNIT FOR REPAIR

2-20. Inside the U.S.A.

2-21. For fast service, return the unit along with the service card safely packaged directly to:

Hewlett-Packard
Instrument Service Center
P.O. Box 7922
690 Middlefield
Mountainview, CA 94042

2-22. Outside the U.S.A.

2-23. Return your unit to the nearest designated Hewlett-Packard Sales and Service Office. Check the back of this manual for the address.

SECTION III
OPERATION

3-1. INTRODUCTION

3-2. This section of the manual has the information and instructions for the operation of the 3468A Multimeter, showing front panel and remote operation. The information is an abbriviated description of the operation and is written for a Service Trained Person, rather than an Operator. For more complete operating instructions, refer to the 3468A's Operators Manual. To familiarize yourself with the front and rear panel features or for a review of instrument operations, refer to Figure 3-1.

3-3. The Operation Section is separated into the following major areas: General Information, Front Panel Operation, Shifted Operation, and Remote Operation (HP-IL). It is suggested that you read the Remote Operation Chapters last, since you need to know the other operations to understand the remote operation. The major areas are as follows:

a. General Information - paragraph 3-4.

Title	Paragraph
AC Power Operation	3-5
Battery Operation	3-7
Turn-On	3-9
Display	3-12
Input Terminals	3-14
Miscellaneous	3-16

b. Front Panel Operation - paragraph 3-19

Title	Paragraph
DC Volts Measurement	3-20
AC Volts Measurement	3-24
Resistance Measurement	3-28
DC Current Measurement	3-32
AC Current Measurement	3-36
Ranging	3-40
Triggering	3-45

c. Shifted Operation - paragraph 3-49

Title	Paragraph
General	3-50
Number Of Digits Displayed	3-53
Autozero	3-56
Self-Test/Reset Operation	3-59
Calibration	3-62

d. Remote Operation - paragraph 3-65.

Title	Paragraph
General	3-66
3468A Response To Loop Messages	3-70
3468A Addressing	3-91
Talk-Only Mode (No Controller)	3-94
3468A HP-IL Programming	3-96
Advanced Programming	3-108

3-4. GENERAL INFORMATION

3-5. AC Power Operation

3-6. Before connecting ac power to the 3468A, make sure the power source matches the power requirement of the multimeter (as marked on the option label at the rear panel). If the instrument is incompatible with the power source, refer to Section II of this manual for power requirement modification.

3-7. Battery Operation (Option 001)

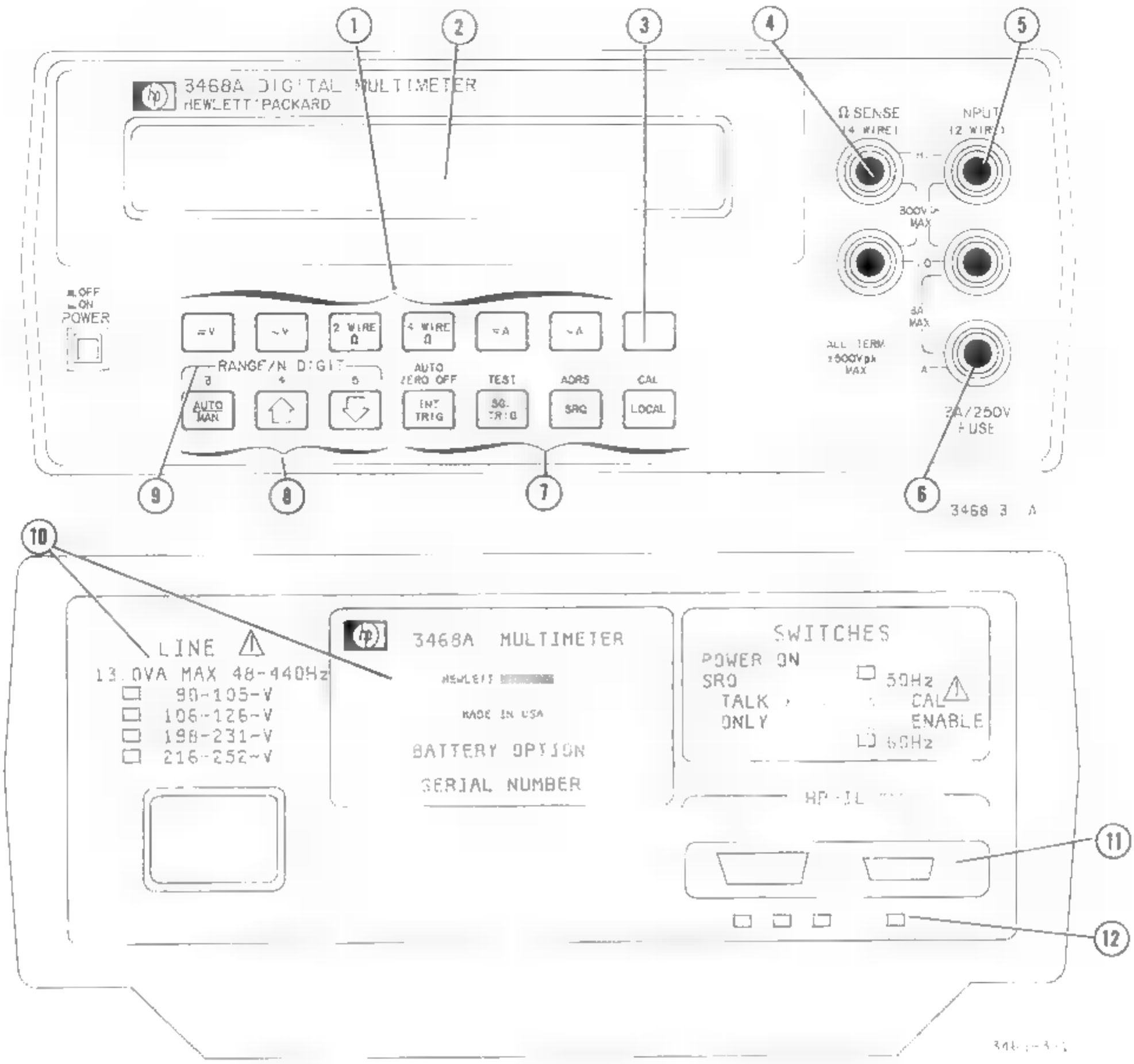
3-8. Make sure the 3468A's battery is charged before operating the multimeter in the battery mode. The maximum charge current is approximately 400mA and is generated when the 3468A is plugged in and its power switch is off. The current is approximately 130mA when the power switch is on. The multimeter will not operate if the battery voltage is below approximately 5.5V (nominal voltage is 6V). Battery voltage can be checked by first pressing ⎓V button and then, with a probe connected to the HI INPUT terminal, touch the battery voltage check pad through the access hole in the bottom cover.

3-9. Turn-On

3-10. When the 3468A is first turned on, the multimeter goes through an Internal Test routine. During the test, all the display segments are lit. When the test is completed and the 3468A passes the test, "SELF TEST OK" will be displayed for about one second. If the Self-Test fails, refer to Section VII of this manual for troubleshooting information. For more information on the Self-Test, refer to paragraph 3-59.

3-11. Once the Self-Test is completed, the 3468A goes to its turn-on state which is:

FUNCTION.....DCV
RANGE.....AUTO
TRIGGER.....INTERNAL
AUTOZERO.....ON
NUMBER OF DIGITS DISPLAYED.....5



(1) Use the measurement keys along the top row to select the type of measurement you want to make.

(2) The 12 character alphanumeric display includes 12 dedicated annunciators. The display is read directly in engineering units, i.e., MV for milli-volts, MOHM for Meg-ohm resistance, etc.

(3) If the blue key is pressed before another key, the function shown above that key is executed.

(4) These terminals are used for the voltmeter sense leads when making 4-wire ohms measurements.

(5) These terminals are the voltmeter and 2-wire ohms input, 4-wire ohms source current terminals.

(6) This is the Amps input terminal and is used with the INPUT LOW terminal. (3 Amp fuse protected)

(7) These keys are used to select special operating features of the 3468A. The blue shift key allows for selecting the "SHIFTED" functions of the bottom row of keys.

The **Internal Trigger** is selected by this key. In this mode, the 3468A triggers itself.

Autozero is a function that allows you to enable or disable the internal zero correction circuitry.

Pressing the **Single Trigger** key causes the 3468A to take one reading and wait for the next trigger impulse.

The **Test/Reset** key performs an internal self test, then resets the 3468A to its turn-on state. Any errors in the self test are noted in the display.

The front panel **SRQ** (Service Request) key is an HP-IL operation that enables you to manually interrupt the controller. This key is enabled by setting the SRQ mask.

The 3468A HP-IB **Address** is displayed when the Address key is pressed.

The **Local** key returns the 3468A to front panel control from the REMOTE mode.

Figure 3-1. 3468A Front and Rear Panel Features

The 3468A features total electronic calibration. The **Cal** key is used as part of that procedure. See Section IV.

(8) The range keys are used to select the proper range for the measurement. Press any of the keys to select the manual range mode. Note the M RNG annunciator in the display. The **Auto/Man** key will return the meter to autorange.

(9) The "SHIFTED" functions of the range keys are used to select alternate numbers of display digits.

(10) The Option Label shows the instrument's power option.

(11) HP-IL Connector.

(12) These switches select the Talk-Only mode, Power-On SRQ feature, correct power line frequency (50Hz or 60Hz), and Cal Enable, left to right respectively.

Figure 3-1. Front and Rear Panel Features (cont'd)

3-12. Display

3-13. The Display is a 12 character alphanumeric Liquid Crystal Display (LCD) with 12 annunciators. The display is normally used to show readings, however, the display can also show alphanumeric messages (sent remotely). The four characters to the right show the function and the 8 characters to the left show the reading (e.g. +.123657 DCV). If a reading is not available (due to a remote programming error), "INVALID" will be displayed. An "OVLD" is displayed if the input is out of range for the selected range and function.

3-14. Input Terminals

3-15. The 3468A has five Input Terminals which are: INPUT HI, INPUT LO, Ω SENSE HI, Ω SENSE LO, and A (Amps) terminal. The INPUT HI and LO Terminals are used for measuring dc volts, ac volts, and resistance in the 2-Wire Ohms configuration. Refer to Figure 3-2 for a typical connection. The Ω SENSE HI and LO Terminals (in conjunction with the INPUT Terminals) are used in the 4-Wire Ohms configuration. Refer to Figure 3-4 for a typical ohms connection. The A (Amps) Terminal with the INPUT LO Terminal is used to measure ac or dc current. Refer to Figure 3-3 for a typical current connection.

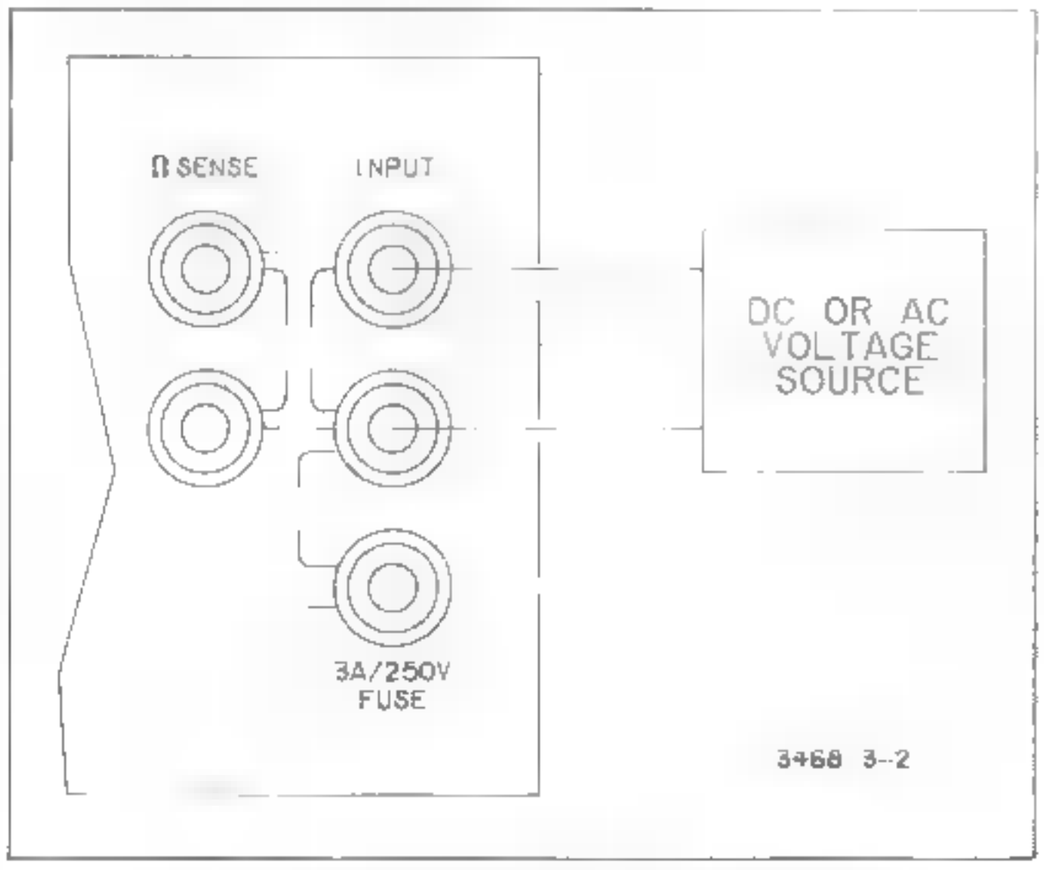


Figure 3-2. Typical Input Measurement Connection

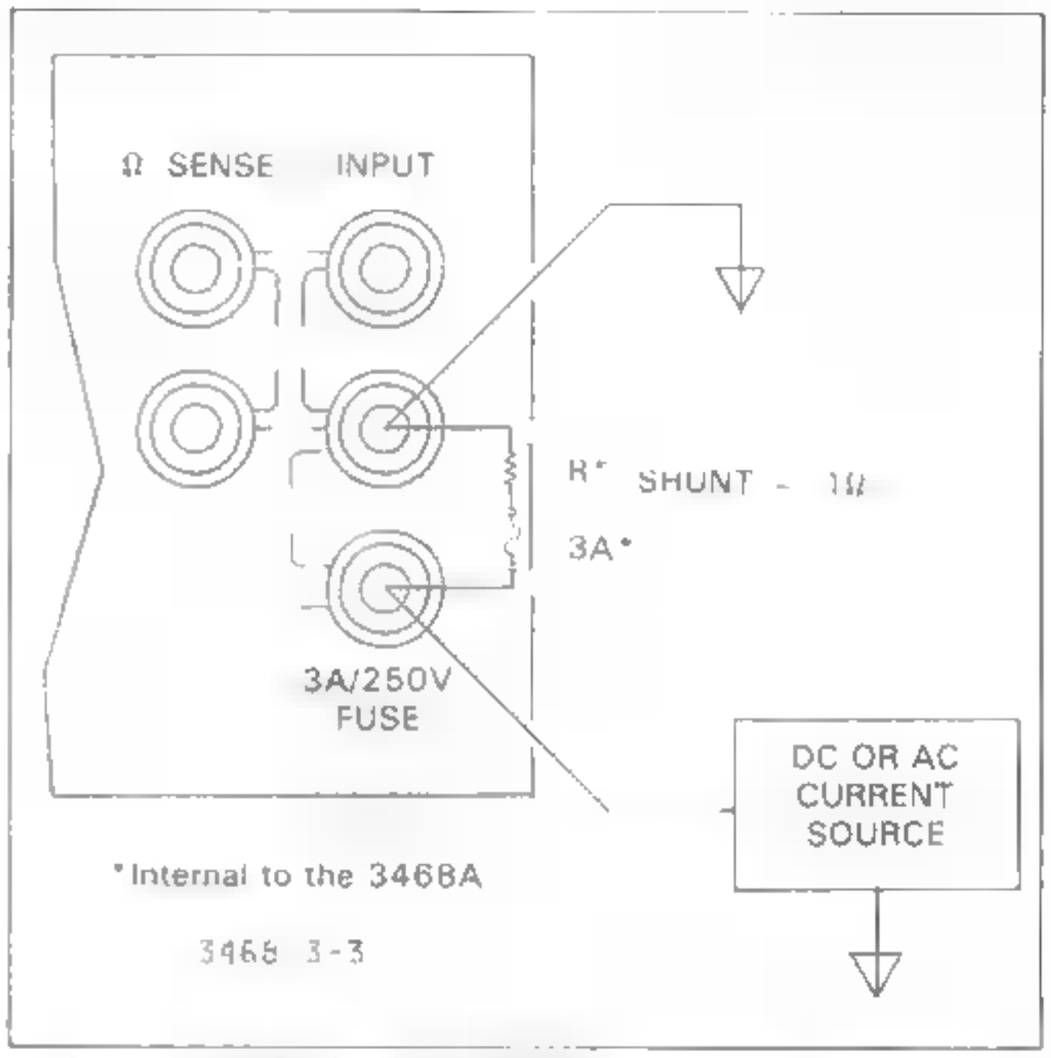


Figure 3-3. Typical Current Measurement Connection

3-16. Miscellaneous

3-17. Option Label. The 3468A has an option label on the rear panel to show the power source to which the instrument is configured. Whenever the 3468A is reconfigured, the option label should be changed to show the new power configuration (see Section II of this manual).

3-18. Information Decal. An information decal showing the capabilities of the 3468A is affixed to the underside of the multimeter. The decal can be used as a quick reference guide for the 3468A.

3-19. FRONT PANEL OPERATION

3-20. DC Volts Measurements

3-21. The 3468A is able to make dc volts measurements from 1uV to 300V in four ranges: .3V, 3V, 30V, and 300V. All ranges are protected from input voltages up to 450V peak. Select the DC Volts Function for dc volts measurements by pressing the ⎓V button.

3-22. In the DC Volts Function, ranging is done in the Input Circuitry of the 3468A. The result is that the input to the A/D Converter (which changes the voltage to digital information) has the same value in all ranges for all full scale inputs (e.g. 10V input to the A/D for .3V, 3V, etc. inputs to the 3468A).

3-23. When the DC Volts Function is selected, the right side of the display shows "VDC" to indicate that the function is selected. The resultant reading can be displayed either as ■ 5 1/2, 4 1/2, or 3 1/2 digit reading, dependent on the selected Number Of Digits Displayed (see paragraph 3-53). Refer to Table 1-1 or Table 4-1 for the DC Volts Function's accuracy specifications.

3-24. AC Volts Measurements

3-25. The 3468A uses a True RMS AC to DC Converter to measure ac voltages from .03V to 300V in four ranges: .3V, 3V, 30V, and 300V. The response of the converter is from 20Hz to 100KHz on all ranges (to 300KHz on the 30V Range only). All ranges are protected from input voltages up to 450V peak. Select the AC Volts Function for ac volts measurements by pressing the ∼V button.

3-26. The AC to DC Converter changes the ac input voltage to dc volts, which is then measured by the 3468A's A/D Converter. All ranging is done in the AC to DC Converter, applying the same voltage value to the A/D Converter for all full scale inputs.

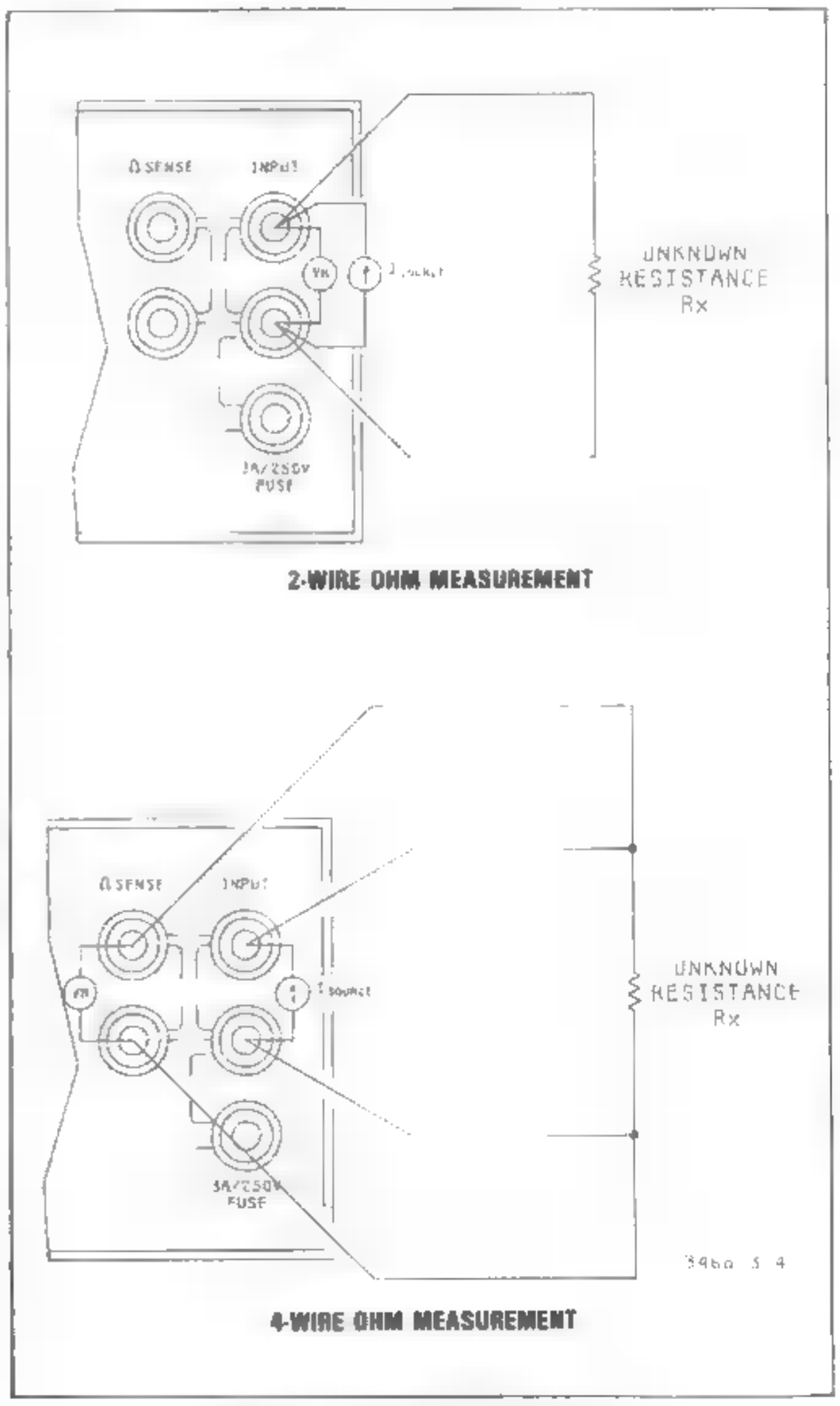
3-27. When the AC Volts Function is selected, the right side of the display shows "VAC" to indicate that the function is selected. The resultant reading can be displayed either as a 5 1/2, 4 1/2, or 3 1/2 digit reading, dependent on the selected Number Of Digits Displayed (see paragraph 3-53). A .6 second delay is also applied in the AC Volts Function before a reading is taken (also, during a range change). Refer to Table 1-1 or Table 4-1 for the AC Volts Function's accuracy specifications.

3-28. Resistance Measurements

3-29. The 3468A is able to make resistance measurements from .001 ohms to 30M ohms in six ranges. The ranges extend from the 300 ohm to the 30M ohm range. All ranges ▬ protected from input voltages up to 350V peak. Resistance measurements can be made using either the 2-Wire or 4-Wire ohms configuration, which are selected by the 2 WIRE ■ and 4 WIRE Ω buttons, respectively. Refer to Figure 3-4 for the correct ohms connections.

3-30. Resistance measurements are made by applying a known current (generated by the 3468A) to the unknown resistance. The resultant voltage drop is then measured by the 3468A's dc circuitry (Input Circuitry and A/D Converter). In the 2-Wire Ohms Function, the voltage drop is measured across the HI and LO INPUT Terminals. In the 4-Wire Ohms Function, the voltage is measured across the HI and LO Ω SENSE Terminals. The Ohms Current Source generates the known current which is applied to the unknown resistance (in both ohms functions) from the HI INPUT Terminal. The current values are as follows:

Range	Current
300 ohm	1mA
3K ohm	1mA
30K ohm	100uA
300K ohm	10uA
3M ohm	1uA
30M ohm	.1uA



2-WIRE OHM MEASUREMENT

4-WIRE OHM MEASUREMENT

Figure 3-4. Ohms Connections

3-31. When an Ohms Function is selected, the right side of the display shows either "OHM", "KOHM", or "MOHM", dependent on the range selected. In addition, the "2Ω" annunciator is on for the 2-Wire Ohms

Function and the "4Ω" annunciator is on for the 4-Wire Ohms Function. The ohms reading can be displayed either as a 5 1/2, 4 1/2, or 3 1/2 digit reading, dependent on the selected Number Of Digits Displayed (see Paragraph 3-53). A .02 second or a .2 second delay is also applied before each reading in the 3M ohm and 30M ohm Range, respectively. Refer to Table 1-1 or Table 4-1 for the Ohms Function's accuracy specifications.

NOTE

The 3468A will show a negative resistance if small negative voltages exist on the circuit under test, or the Ohms Sense and Input Leads are reversed from each other. This only happens in the 4-Wire Ohms Function.

3-32. ■ Current Measurements

3-33. The 3468A can make dc current measurements from 10uA to 3A in one range: 3A. The range is protected from excessive currents and voltage by a 3A 250V fuse. Select the DC Current Function to measure dc currents by pressing the ⎓ A button.

3-34. In the DC Current Function, the current is applied between the INPUT LO and A Terminals. Since a known value resistor (.1 ohm) is connected between the terminals, a voltage proportional to the unknown current and the resistor is generated. This voltage is measured by the 3468A's dc circuitry (Input Circuitry and A/D Converter).

3-35. When the DC Current Function is selected, the right side of the display shows "ADC" showing the function selected. The readings can be displayed either as a 5 1/2, 4 1/2, or 3 1/2 digit reading, depending on the selected Number Of Digits Displayed (see paragraph 3-53). Refer to Table 1-1 or Table 4-1 for the DC Current Function's accuracy specifications.

CAUTION

The current function is protected by a fuse of 250 V rating. To avoid damage to the Multimeter, current sources having open circuit voltages greater than 250 V (dc + peak ac) must not be connected to the A (amps) input terminal.

NOTE

Current inputs of greater than 1 amp may cause internal heating of the multimeter which, if sustained for more than 30 seconds, may cause inaccuracies. Allow sufficient time for the circuitry to settle after measurement is complete and before other critical measurements are made.

3-36. AC Current Measurements

3-37. The 3468A can make ac current measurements from 30mA to 3A in two ranges: 300mA and 3A. The frequency response is from 20Hz to 20KHz. The ranges are protected from excessive currents and voltage by ■ 3A 250V fuse. Select the AC Current Function to measure ac currents by pressing the ~ A button.

3-38. The AC Current Function is similar to the DC Current Function (see paragraph 3-32); a voltage drop across a resistor is measured. The difference is that the resultant ac voltage is changed from ac to dc using the AC to DC Converter. Similar to the AC Volts Function, all ranging is done in the converter.

3-39. When the AC Current Function is selected, the right side of the display shows "AAC", showing the function selected. The readings can be displayed either as a 5 1/2, 4 1/2, or 3 1/2 digit reading, dependent on the selected Number Of Digits Displayed (see paragraph 3-53). Refer to Table 1-1 or Table 4-1 for the AC Current Function's accuracy specifications.

3-40. Ranging

3-41. The 3468A has two range modes: Manual and Autorange. Manual ranging is selected by pressing the AUTO/MAN button (if the 3468A is in Autorange) or by pressing either the △ or ▽ buttons. The "M RNG" annunciator on the display then turns on. The following explains the different range modes.

3-42. Uprange. The 3468A upranges to the next higher range each time the △ button is pressed. The highest selectable range depends on the function selected (e.g. 300V for the AC Volts and DC Volts Functions). If a function is selected with its highest range lower than the previous range, the multimeter defaults to the new highest range.

3-43. Downrange. The 3468A downranges to the next lower range each time the ▽ button is pressed. The lowest selectable range depends on the function selected (e.g. .3V for the DC Volts Function). If a function is selected with its lowest range higher than the previous function, the multimeter defaults to the new lowest range.

3-44. Autorange. The 3468A selects the optimum range when this mode is selected. The mode is selected when the 3468A is first turned on or by pressing the AUTO/MAN button (if in Manual Range). When Autorange is enabled, the 3468A upranges when the reading is at or above ±30100 and downranges at or below ±027000. The numeric range points are irrespective of decimal placement. Refer to Figure 3-5 for the autorange points (the example is for the DC Volts Function; other functions are similar).

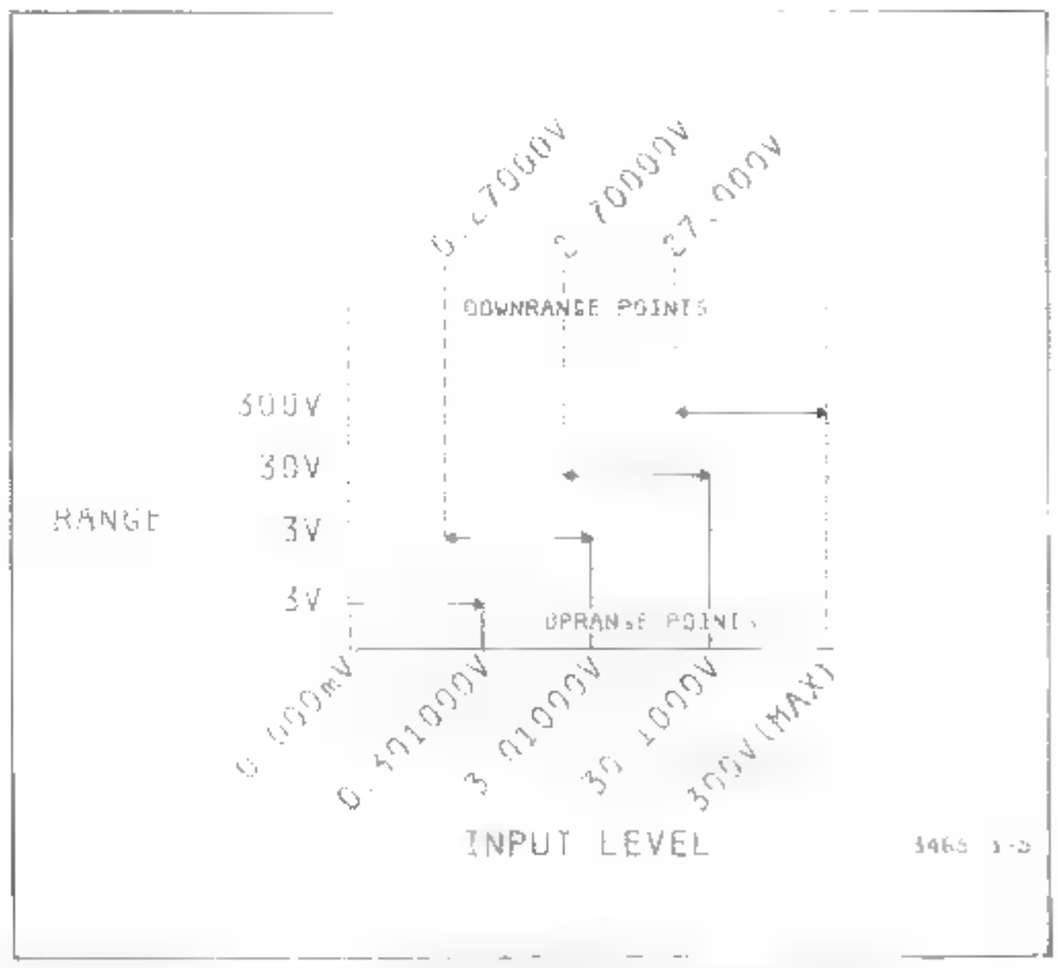


Figure 3-5. Autoranging Points

3-45. Triggering

3-46. The 3468A has two trigger modes: Internal and Single. The following paragraphs explain the trigger modes.

3-47. Internal Trigger. In this mode, the measurement cycle is internally initiated and the 3468A makes the measurements at the maximum reading rate. The Internal Trigger is selected at instrument turn on or by pressing the INT/TRIG button.

3-48. Single Trigger. In this mode, a measurement cycle is initiated each time the SGL/TRIG button is pressed. When the button is initially depressed, the 3468A initiates a measurement cycle and then places the multimeter in the Single Trigger mode. The "S TRG" annunciator on the display also turns on, when the SGL/TRG button is pressed. If the button is pressed during ■ measurement cycle (while in the Single Trigger mode), the 3468A starts a new measurement cycle. When the cycle is completed, a new cycle can then be initiated by pressing the button.

NOTE

When the 3468A is in the Single Trigger mode and an attempt is made to change range or function, the left portion of the display goes blank (except for the decimal point) until another reading is taken (instrument triggered).

3-49. SHIFTED OPERATION

3-50. General

3-51. The Shifted Operation of the 3468A is used to expand the capabitities of the multimeter using the same number of front panel pushbuttons. This is done by using the bottom row of front panel buttons for two different operations, shifted and unshifted. An unshifted operation (AUTO/MAN, INT/TRIG, etc.) is normally selected by pressing a single button. A shifted operation is done by first pressing the blue "SHIFT" button (on the right end of the upper row of buttons) and then pressing one button (on the lower row). To select a new shifted operation, press the blue button again and the button for the new operation. Table 3-1 lists the shifted operations and corresponding buttons. The shifted operations are also shown in blue lettering above the buttons.

3-52. When the blue Shift button is pressed, the "SHIFT" annunciator on the display is on. The annunciator remains on until a different button is pressed.

Table 3-1. Shifted Operations

Shifted Operation	Select Button	Description of Operation
3 Digit (Disp)	AUTO/MAN	Selects 3 Digits Displayed (see paragraph 3-53).
4 Digit (Disp)	⇧	Selects 4 Digits Displayed (see paragraph 3-53).
5 Digit (Disp)	⇩	Selects ■ Digits Displayed (see paragraph 3-53).
AUTOZERO	INT/TRIG	Turns Autozero on or off (see paragraph 3-56).
TEST/RESET	SGL/TRIG	Places the 3468A into its Internal Test Mode (see paragraph 3-59).
ADRS	SRQ	Displays, the 3468A's current HP-IL Address. Code (see Paragraph 3-92).
CAL	LOCAL	Places the 3468A into the calibration mode

3-53. Number Of Digits Displayed

3-54. The 3468A can display readings in either 5 1/2, 4 1/2, or 3 1/2 digits. The 5 1/2, 4 1/2, and 3 1/2 digits can be selected by first pressing the blue Shift button and then either the AUTO/MAN, ⇧, or ⇩ button, respectively.

3-55. The Number Of Digits Displayed affects the reading rate of the multimeter. This is because the number of digits determines the integration time of the A/D Converter. In the 4 1/2 digit mode, the integration time is 1/60 second (or 1/50 second for the 50Hz option), which is called 1 PLC (Power Line Cycle). In the 3 ½ digit mode, the time is 1/600 second (for both 60Hz and 50Hz options), which is .1 PLC. In the 5 ½ digit mode, the 3468A takes 10 readings using the 4 ½ digit mode and averages them together for an extra digit of

resolution. This takes a time of 1/6 second (or 1/5 second in the 50 Hz option) which is 10 PLC. For more information on the integration time and the A/D Converter, refer to this manuals Section VII (chapter on the A/D Converter theory of operation).

3-56. Autozero

3-57. The Autozero Function of the 3468A is used to compensate for offsets that may be present in the multimeter's internal circuitry (DC/Ohms Input Amplifier, A/D Converter, etc.). The method used is to temporarily connect the input of the input amplifier to ground (INPUT LO Terminal) and take a measurement (the INPUT HI Terminal is open at this time). The offset reading is then stored into the 3468A's internal memory. After that, the short is removed and a regular input measurement is made. The offset reading is then subtracted from the input reading and the compensated reading is displayed.

3-58. The Autozero feature is enabled when the 3468A is turned on and after doing a Self-Test (see Paragraph 3-59). The feature can be disabled by pressing the blue Shift button and then the INT/TRIG button. The "AZ OFF" annunciator on the display will light, showing that the function is off. After the function is turned off, the multimeter immediately takes an offset reading and stores it into memory. This last reading is then subtracted from the input measurements that follow. Since no more offset readings are taken, the reading rate of the 3468A is faster (up to twice as fast). If a range, function, or digit change is made, or an attempt is made to calibrate the 3468A, a new offset reading is taken. With Autozero off, the 3468A's input circuitry remains in a static state. This is useful when making measurements in extremely high impedance circuits where the internal switching transients of the 3468A may affect the reading accuracy.

NOTE

The 3468A's long term stability may be affected, if the Autozero feature is disabled.

3-59. Self-Test/Reset Operation

3-60. The 3468A uses an Internal Self-Test to check its display and internal circuitry. The multimeter goes through the test at turn-on and also by pressing the blue Shift button and then the SGL/TRG (TEST/RESET) button. When the test is selected, all the segments of the display (except the upper dots of the colons) are on for about five seconds. After the Self-Test is completed, the display indicates "SELF TEST OK" (if the test passes) for about one second. The 3468A then goes back to its turn-on state (see paragraph 3-9), not the previous state. If you wish to view the message longer than normally displayed, hold the SGL/TRG (TEST/RESET) button down and the message remains on the display. After the button is released, the 3468A then goes to its turn-on state.

3-61. If the Self-Test fails, an error message will be displayed for about one second. The message is "ERROR dd", where dd is the summation of the individual error numbers (an error number pertains to a test failure). This message can also be viewed longer than normally by holding the SGL/TRG (TEST/RESET) button down. The error numbers and corresponding failures are [redacted] follows:

Error Number	[redacted] Failure
1	Calibration RAM Error
2	RAM Error
4	ROM Error
8	A/D Converter Error

3-62. Calibration

3-63. The 3468A does not have any adjustments to calibrate the instrument; calibration is done electronically. A known good calibration source is applied to the instrument and the value of the known source is entered into the instrument. A reading is then taken and compared with the entered value. A Calibration Constant is calculated (from the entered value) to correct the reading to the known value, and then stored into the instrument's memory. The correct readings are then calculated using the constants and then displayed.

3-64. When calibrating the 3468A, first the rear panel switch number 8 has to be set to CAL ENABLE (down). Then the calibration process becomes a simple four step procedure: configure the instrument to the desired function and range, apply a known source, set the display, and start the calibration cycle. These steps can be performed either from the front panel or remotely. Refer to Section IV for further calibration procedures.

NOTE

The CAL ENABLE Switch on the rear panel should not be in the CAL/ENABLE position under normal use. It should only be in that position to calibrate the instrument.

3-65. REMOTE OPERATION

3-66. General

3-67. The following paragraphs give device dependent information necessary to remotely operate the 3468A over the Hewlett-Packard Interface Loop (HP-IL). Directions for mechanical interface connections to the HP-IL are given in Section II of this manual. Familiarize yourself with the front panel operation

(local) before attempting to use the multimeter in remote (HP-IL).

3-68. The Hewlett-Packard Interface Loop is a two wire, serial interface that permits communication from one device to another. A general description of the HP-IL is in this manual's Appendix A. Refer to the appendix for any non-3468A related HP-IL information.

3-69. The following lists the different 3468A remote operations. Note that not all controllers will be capable of executing all Loop messages. Refer to the Operators Manual for more information on programming the 3468A. The Operators Manual covers programming the 3468A with BASIC language controllers such as the -hp-Model 85 as well as RPN language controllers such as the -hp-Model 41C/CV. This section assumes that the reader has a general understanding of programming.

a. 3468A Response to Bus Messages (paragraph 3-70).

Title	Paragraph
Data	3-72
Trigger (GET)	3-73
Clear (DCL or SDC)	3-74
Remote	3-75
Local	3-76
Local Lockout	3-77
Clear Lockout and Set Local	3-78
Require Service (SRQ)	3-79
Status Byte	3-81
Programming the SRQ Mask	3-86
Status Bit	3-88
Pass Control	3-89
Abort	3-90

b. 3468A Addressing (paragraph 3-91) and Talk-Only Mode (paragraph 3-94).

c. 3468A HP-IL Programming (paragraph 3-96).

Title	Paragraph
General	3-97
Program Codes	3-99
Power-On SRQ	3-101
Sending Data to the Display	3-102
Reading Data from the 3468A	3-104
Data Ready Feature	3-106
Front Panel SRQ	3-107

d. Advanced Programming (paragraph 3-108).

Title	Paragraph
General	3-109
Extended Ohms Operation	3-110
Reading the Binary Status Byte	3-111

3-70. 3468A Response to Loop Messages

3-71. The following paragraphs explain the 3468A's response to Loop Messages. The multimeter's Loop capabilities are in Table 3-2.

Table 3-2. 3468A's Loop Capabilities

Mnemonic	Interface Function Name
R	The 3468A handshakes as a receiver
D	Handshakes as a driver to the next device
AH	Handshakes as an acceptor
SH1	Handshakes [illegible] source
T1,2,3,5,6	Basic Talker, Send Status, Send Device ID, Talk Only and unaddressed as a Talker when addressed to Listen
TE0	No extended talker capability
L1,3	Basic Listener and unaddressed to listen when addressed to Talk
LE0	No extended Listener capability
C0	The 3468A cannot serve as a controller
AA1	Can be autoaddressed by the controller
AE0	No extended addressing capability
AM0	No multiple addressing capability
DC2	The 3468A responds to Device Clear and Selected Device Clear
DT1	The 3468A responds to Device Trigger
RL2	Basic Remote, Local, and Local Lockout capability
SR2	Basic Service Request and Asynchronous Service Request capability
PP0	No Parallel Poll capability
MS1	The 3468A does have Manual Service Request capability
PD0	No power-down capability
DD0	The 3468A does not implement Device Dependent Talker or Listener commands

3-72. Data. The Data Message is used to transfer information between the 3468A and the controller.

a. The message is used to send data to the multimeter and consists primarily of set-up information (e.g. DCV, 30V Range, etc.). The 3468A is the Listener and the controller is the Talker.

b. The message is also used by the controller to receive data from the 3468A. This includes the multimeter's output (readings) and status information. In this case, the 3468A is the Talker and the controller is the Listener.

3-73. Trigger (GET, Group Execute Trigger). The Trigger message causes the 3468A to initiate a measurement cycle. It is an HP-IL Trigger and triggers the multimeter in either trigger mode, since it has priority over the other trigger modes. If the 3468A is triggered during a measurement cycle, the cycle is aborted and a new cycle is initiated. The multimeter has to be programmed to "listen" to execute the trigger.

3-74. Clear (DCL or SDC: Device Clear or Selective Device Clear). A Clear places the 3468A into its turn-on state. In addition, the SRQ Mask is set to zero or octal 200 (if the Power-On SRQ switch is on, see (paragraph 3-101).

3-75. Remote. The Remote Message allows the 3468A to be controlled over the HP-IL. In remote, the front panel buttons, except the LOCAL and Front Panel SRQ buttons, are disabled. The Local and Front Panel SRQ buttons are disabled when the 3468A is in remote and local lockout (see paragraph 3-77). The instrument state in remote is determined by the local state before being placed in remote. The RMT annunciator on the display will also be on with the 3468A in remote.

3-76. Local. This message clears the remote operation of the 3468A and enables its front panel operation. Pressing the front panel LOCAL button also places the multimeter in the local state (if the button has not been disabled by the Local Lockout Message, see next paragraph).

3-77. Local Lockout. All the front panel buttons are disabled with this message, if the 3468A is in remote. The message is in effect until cleared over the HP-IL or power is cycled.

3-78. Clear Lockout and Set Local. This message placed the 3468A into local and the Local Lockout Message is cleared.

3-79. Require Service (SRQ). The Require Service Message (SRQ Message) is independent of all other HP-IL activity. The 3468A must be programmed to send the SRQ Message. This is done by programming the SRQ Mask (see paragraph 3-86). The front panel SRQ annunciator is ■ when the 3468A requires service.

3-80. Since more than one device (on the same Loop) can output the SRQ Message, the devices can be polled by the controller (by a Serial Poll) to determine if the 3468A (or another device) requires service. The 3468A then outputs a Status Byte (see paragraph 3-81) which shows for what reason the multimeter requires service.

3-81. Status Byte. The Status Byte is output by the 3468A in response to ■ Serial Poll. The message has the same information as the 3468A's Status Register (see next paragraph), and sets the corresponding bit true for any true SRQ condition shown in Table 3-4 (whether the SRQ Mask is set or not). The bit is represented in Figure 3-6.

3-82. The 3468A can require service if any condition in Table 3-3 is true. Since the SRQ Mask must be set to output the Require Service Message (except for bit 7, which is set by the Power-On SRQ switch), the 3468A's Status Register is used to monitor the conditions. This way, only the condition that is set by the mask outputs the SRQ Message. Other true conditions that can cause an SRQ Message, but which are not set in the SRQ Mask, remain in the Status Register as ■ true condition. They will not cause the SRQ Message to be output. For example, suppose the Front Panel SRQ condition is the only one set in the SRQ Mask. If the Data Ready condition is true, but not Front panel SRQ, no SRQ Message is output (the Status Register's Data Ready bit is true). The only way the SRQ Message is output is if the Front Panel SRQ condition is true. Both the Front panel SRQ bit and the Data Ready bit will then be true in the Status Register.

Table 3-3. Status Byte Definitions

Octal Code	Decimal Code	Bit	Definitions
001	1	0	Data Ready - Indicates to the controller that measurement data is ready to be output. The Require Service Message and bit is cleared when the controller begins to accept the data or when the reading is no longer available. See paragraph 3-110.
002	2	1	This bit will be true if the 3468A receives an invalid combination of range and function codes. The bit will be cleared when a valid combination is selected.
004	4	2	Syntax Error - This shows that an invalid Program Code(s) has been sent to the 3468A (e.g. F9).
010	8	3	Internal Error - Shows that ■ failure in the 3468A is detected. This may be a failure in the Self-Test Routine (see paragraph 3-56), the A/D Converter, or a checksum error in the Calibration RAM (checked every time a reading is taken). More information can be obtained by reading the 3468A's error register. See paragraph 3-116.
020	16	4	Front Panel SRQ - This bit is set when the 3468A's Front Panel SRQ button is pressed. See paragraph 3-111.
040	32	■	Invalid Calibration - When this bit is set, an attempt to calibrate the 3468A has failed.
100	64	6	This is the RQS bit. This bit is true only when the 3468A requires service from the controller.
200	128	7	Power-On SRQ - Shows that a power-on reset has occurred. See paragraph 3-102.

Note: More than one bit in the Status Byte can be true (see paragraph 3-83).

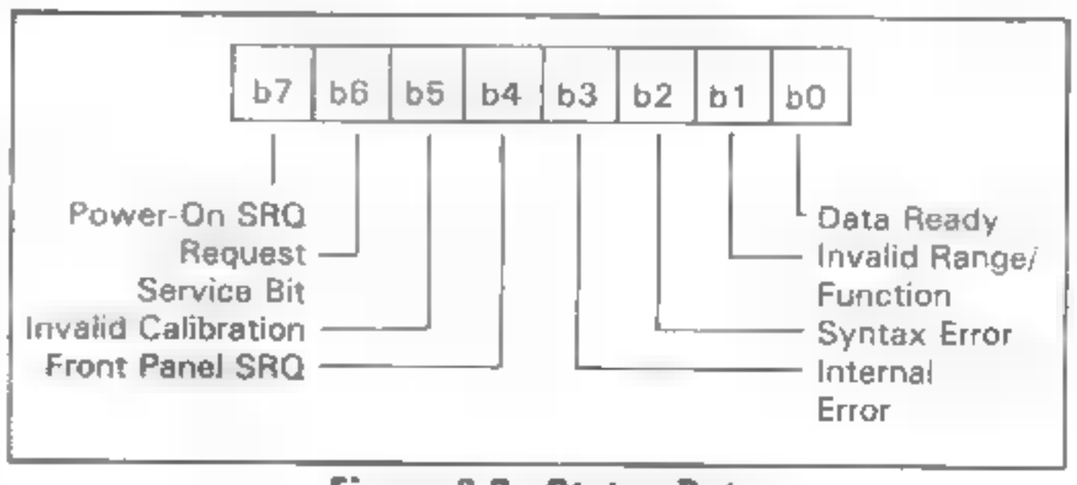


Figure 3-6. Status Byte

3-83. More than one bit in the Status Byte Message can be true. For example, bit 0, 2, and 4 ■ true (remember, bit 6 is true for any RQS condition, if the SRQ Mask is

set for the condition) making the resultant Status Byte looks like the following:

b7							b0
0	1	0	1	0	1	0	1

NOTE

A "1" in this example shows a true condition.

3-84. The byte is output as shown in the previous example with the corresponding octal number of the example at 125 (shown as follows).

01 010 101

125

3-85. The Status Byte together with the Service Request (SRQ) Mask determine when the Require Service (RQS) bit is to be set. Setting RQS causes SRQ to be sent on the HP-IL. Execution of a Serial Poll for the 3468A will clear SRQ and it will remain clear until another reason for setting RQS occurs. RQS, on the other hand, is set if one or more corresponding bits in the Status Byte and SRQ Mask are both set. RQS is cleared whenever all corresponding bits are not both set. A Serial Poll then, may cause RQS to be cleared but not in all cases. Bits 2, 4, 5, and 7 are cleared with ■ Serial Poll.

3-86. Programming the SRQ Mask. The SRQ Mask must be set for the 3468A to output a Require Service Message. Setting the SRQ Mask will not set the bits in the Status Byte; these bits are automatically set (except bit 6) when any corresponding require service condition is true. For example, you wish to know if the multimeter has received an incorrect program code (Syntax Error) or has ■ internal failure (Internal Error). If the conditions are true, bits 2 and 3 of the Status Byte are set; but no Service Request Message is sent. The message will not be output until the SRQ Mask is set to the corresponding bits of the Status Byte (which are are bits 2 and 3). Since the mask is to be set in octal, the resultant code for the bits is "14". The mask is set by sending "Mdd", where dd is the octal code for the bits.

3-87. Only bits 0 to 5 can be set by programming the SRQ Mask. Bit 6 of the Status Byte is set whenever the Require Service Message is output and bit 7 is set by the Power-On SRQ switch on the rear panel (see paragraph 3-101). Because of this, only a two digit octal code (00 to 77) can be sent to program the mask. The mask can be cleared by sending: "M00". Remember, the mask is only set to output ■ Require Service Message (not the Status Byte) for ■ certain SRQ condition.

3-88. Status Bit. The 3468A does not respond to a Parallel Poll. The Status Bit is used only for Parallel Poll and should not be confused with the bits in the Status Byte Message.

3-89. Pass Control. The 3468A does not have controller capabilities.

3-90. Abort (Interface Clear). All HP-IL communication is terminated (including the 3468A's Loop communication). Control is returned to the controller. The Abort Message does not remove the 3468A from remote control.

3-91. 3468A Addressing

3-92. Each device in the loop is assigned an address by the controller. The assigned address will probably be different than the factory preset address. The 3468A, for example, has ■ preset address of 22. The address permits the controller to specify or select ■ particular device in the loop when sending commands. Addresses are assigned sequentially around the loop in the direction of information flow. The first device in the loop, after the controller, is assigned an address of 1. The second device in the loop is assigned an address of 2, and so on around the loop until all devices have been addressed. If the 3468A is the only device in the loop with the controller, it will be assigned an address of 1.

3-93. Refer to Figure 3-7. It shows ■ controller and four devices with their basic capabilities, assigned loop addresses, and the direction of information flow. Remember that the controller automatically assigns addresses to devices in the loop.

3-94. Talk-Only Mode (No Controller)

3-95. The 3468A's Talk-Only Mode allows the multimeter to send measurement data to ■ external device (like a printer) without ■ Loop controller. The multimeter is placed into the Talk-Only Mode by setting switch 1 (on the 3468A rear panel) to 1 (up). Measurement data is then output after each trigger. Function and range settings are selected from the front panel.

3-96. 3468A HP-IL Programming

3-97. General. The following paragraphs explain how to program the 3468A over the HP-IL. If information is desired using controller dependent language, refer to the 3468A's Operator's Manual.

3-98. Programming the 3468A is done by DATA messages. Set-up information (Range, Function, etc.) is DATA sent by the controller and is done using program codes. The DATA received by the controller (from the 3468A) is measurement data, and as well ■ other data like the Status Byte and the 5 bytes from the Output Binary Status Byte.

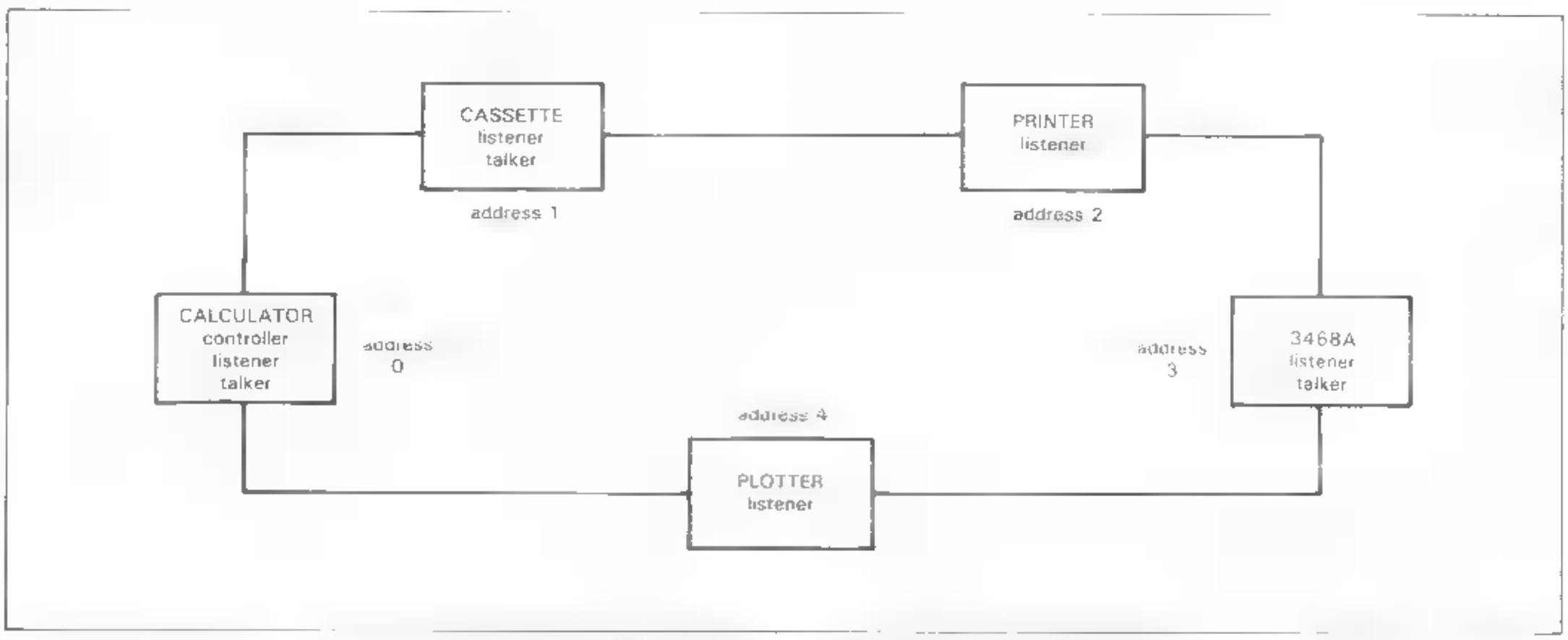


Figure 3-7. HP-IL Addressing

3-99. Program Codes. All the program codes for the 3468A are listed in Table 3-4. The 3468A must be in "remote" and "listen" to receive the codes (the RMT and LSTN annunciators are on when the 3468A is in remote and listening).

3-100. The Program Codes are a series of 8-bit ASCII characters. All lower case characters, spaces, commas, and semicolons are ignored (they may be used with the codes as separators). All null characters, carriage return, line feed, form feed, vertical tab, and horizontal tab characters are also ignored. Other characters which are not included in Table 3-4, cause a Syntax Error (bit 2 in the Status Register set). In addition, a Syntax Error is caused if the characters are sent in ■ different order than shown in the table (e.g. "1F" causes ■ Syntax Error).

Table 3-4. 3468A Program Codes

Type	Program Code	Description
FUNCTION	F1	DC Volts
	F2	AC Volts
	F3	2-Wire Ohms
	F4	4-Wire Ohms
	F5	DC Current
	F6	AC Current
	F7	Extended Ohms (see paragraph 3-110)
RANGE	R1	.3V, 300 Ohm, 3 Amp. Extended Ohms
	R2	3V, 3K Ohm, 3 Amp (AC only)
	R3	30V, 30K Ohm
	R4	300V, 300K Ohm
	R5	3M Ohm
	R6	30M Ohm
DIGITS DISPLAYED	N3	3 1/2 Digits Displayed
	N4	4 1/2 Digits Displayed
	N5	■ 1/2 Digits Displayed
TRIGGER	T1	Internal Trigger
	T2	Single Trigger

Table 3-4. 3468A Program Codes (Cont'd)

Type	Program Code	Description
AUTOZERO	Z0	Autozero Disabled
	Z1	Autozero Enabled
DISPLAY	D1	Normal Display Operation
	D2	Display Text and update Annunciators
MISC. COMMANDS	B1	Read Status of the 3468A in Binary (see paragraph 3-115)
	C	Calibrate (see Section IV of this manual)
	Mdd	Set SRQ Mask (Mdd, where dd is the octal code of the bits)

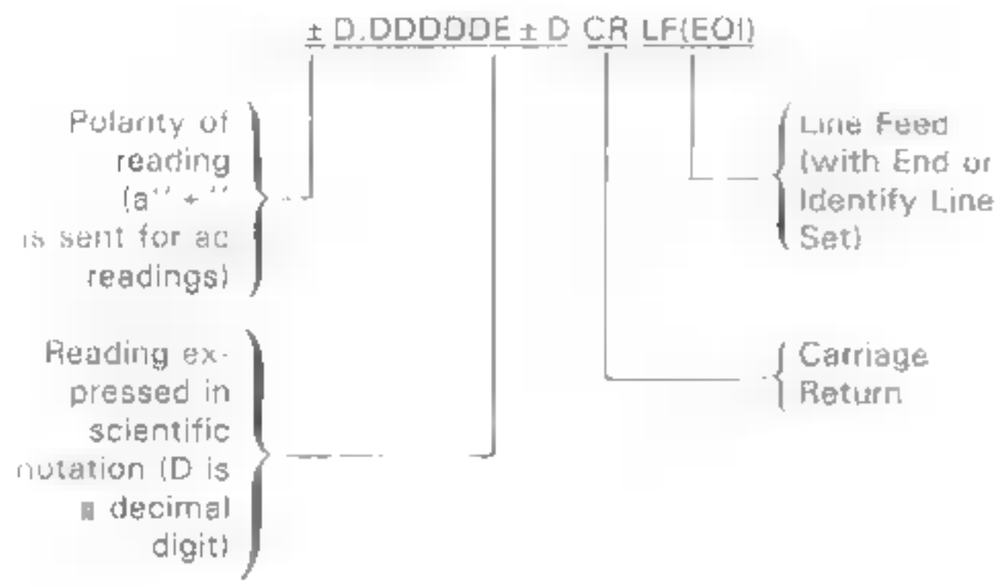
3-101. Power-On SRQ. This feature is enabled by setting the Power-On SRQ switch to On (switch # on the rear panel in the up position). When the feature is enabled, the 3468A Requests Service (generates an SRQ) each time power is cycled or ■ reset condition is generated by the instrument (e.g. due to an instrument failure or selecting the Self-Test).

3-102. Sending Data to the Display. Up to 12 ASCII characters can be displayed at ■ time by the 3468A's display. The legal characters are decimal 32 through 95 of the 128 ASCII characters. Only upper case letters and numbers can be displayed. Lower case letters generate characters which do not resemble the letters. Commas, periods, and semicolons can go between characters.

3-103. The display message mode is enabled by program code "D2" (e.g. "D23468A DMM" where "3468A DMM" is the message displayed). In this mode, the annunciators continue to be updated. If more than 12 characters are sent to the display, the extra characters are ignored until ■ control character is received. If the control character is different than HT (Horizontal Tab),

VT (Vertical Tab), LF (Line Field), CR (Carriage Return), or FF (Form Feed), a Syntax Error is generated. A "D2" code locks the display until a "D1" (Selects Normal Display) is sent, a CLEAR message is sent, an error condition occurs, or a front panel button is pressed.

3-104. Reading Data from the 3468A. Data in the form of readings can be output by the 3468A over the HP-IL (other data that can be output is discussed in later paragraphs). To output a reading (if available), the 3468A has to be addressed to "talk". The readings are output using 13 ASCII characters and are in the following form.



3-105. Each character in the output statement (except EOI) is one byte, which adds up to 13. The exponent will be in engineering notation (E-3, E+0, E+3, or E+6) and the mantissa will always have 1, 2, or 3 digits before the decimal point (D.DDDDD, DD.DDDD, or DDD.DDD). If the 3468A is in the 4 1/2 or 3 1/2 Digit mode, the 5th and/or 6th digits will be output as zeroes. An overload condition (whether plus or minus) will be output as: +9.99999E+9. If a different output is requested (Binary, Front/Rear Switch position, etc.), the other output supercedes the reading. If a data transfer is interrupted while being output, the 3468A continues the output wherever it left off, when addressed again. This partial output (or any output) can be disabled by a Group Execute Trigger (GET), Clear Message (DCL or SDC), sending any valid program code, or pressing the LOCAL, SHIFT, and TEST/RESET buttons on the front panel.

3-106. Data Ready Feature. The Data Ready feature of the 3468A, when enabled, outputs a Service Request Message (SRQ) after each completed measurement cycle. Before the message can be output, bit 0 of the SRQ Mask must be set. This is done by sending program code "M01" (bit 0 of the Status Byte and Status Register). When the Service Request Message is sent, the front panel "SRQ" annunciator turns on and bit 0 of the Status Byte is set. The SRQ condition remains until the data is read by the controller, or a Serial Poll is done.

3-107. Front Panel SRQ. The Front Panel SRQ feature of the 3468A outputs a Service Request Message (SRQ) each time the Front Panel SRQ button is pressed. Before the message can be output, bit 4 of the SRQ Mask must be set. This is done by sending program code "M20" (bit 4 of the Status Byte and Status Register). Once this is done, the Service Request Message will be output and the front panel SRQ annunciator turns on, whenever the SRQ button is pressed. The SRQ condition remains until a Serial Poll is done by the Controller.

3-108. Advanced Programming

3-109. General. The following paragraphs have advanced programming information for the 3468A. It includes Extended Ohms Operation and Reading the Binary Status Byte.

3-110. Extended Ohms Operation. This operation (or function) is only available over the HP-IL and is used to measure resistance above 30M ohm. The function is selected by sending program code "F7R1". The 3468A is set to the 2-Wire Ohms Function and the 30M ohm Range. A 10M ohm resistor is connected in parallel with the input. Measure the internal resistor first and then measure the unknown resistance. The unknown resistance can then be calculated by this formula:

$$R_x = \frac{R_i \cdot R_t}{R_i - R_t}$$

where R_x is the unknown resistance, R_i is the measured 10M ohm resistor, and R_t is the measured value of the parallel combination.

3-111. Reading the Binary Status Byte. The current state of the 3468A can be determined by reading the Binary Status Byte of the instrument. When program code "B1" is sent, the 3468A outputs five bytes which are each 8 bits wide. The corresponding meaning of the bits (when true) are in Table 3-5. Once the status byte is read, the Error Register (byte 4; see Table 3-5) will be cleared. However, if the error still exists and the instrument is triggered, the corresponding bit of the error will again be set in byte 4.

Table 3-5. Binary Status Byte Definition

Byte #		Definition
1	Bits True	Function, Range, and Number Of Digits Displayed
	XXXXXX01	5 1/2 Digits Displayed
	XXXXXX10	4 1/2 Digits Displayed
	XXXXXX11	3 1/2 Digits Displayed
	XXX001XX	Same as R1
	XXX010XX	Same as R2
	XXX011XX	Same as R3
	XXX100XX	Same as R4
	XXX101XX	Same as R5
	XXX110XX	Same as R6
	XXX111XX	Same as R7
	001XXXXX	DC Volts Function
	010XXXXX	AC Volts Function
	011XXXXX	2-Wire Ohms Function
	100XXXXX	4-Wire Ohms Function
	101XXXXX	DC Current Function
	110XXXXX	AC Current Function
	111XXXXX	Extended Ohms Function
2	Bit#	Instrument Status Bits
	0	1 = Internal Trigger, 0 = single Trigger
	1	1 = Autorange Enabled
	2	1 = Autozero Enabled
	3	1 = 3468A set for 50Hz Operation
	4	1 = Calibration RAM Enabled
	5	Not used (always 0)
	6	Not used (always 0)
	7	Not used (always 0)
3	Bit#	SRQ Mask Bit Definition
	0	1 = Data Ready bit set for SRQ on each complete reading
	1	1 = SRQ when invalid range/function combination
	2	1 = Syntax Error - SRQ if Syntax Error occurs
	3	1 = Internal Error - SRQ if Hardware Error occurs
	4	1 = Front Panel SRQ - SRQ if SRQ button is pressed
	5	1 = Calibration Error - SRQ if CAL procedure failed
	[illegible]	Not used (always 0)
	7	1 = Power-On SRQ - PON SRQ switch [illegible] last time power was turned on or DCL message was received
4	Bit#	Internal Error Information
	0	Set if any of the Calibration RAM locations have incorrect checksums or if a range with an incorrect checksum is selected
	1	The Main CPU RAM Self-Test has failed
	2	The ROM Checksum incorrect during Self-Test
	3	An A/D Slope Error was detected
	4	Not used (always 0)
	5	Not used (always 0)
	6	Not used (always 0)
	7	Not used (always 0)
5		A/D DAC Value A decimal value between 0 to 63 represents the setting of the internal Digital to Analog Converter (DAC).

SECTION IV
PERFORMANCE TEST AND CALIBRATION

4-1. INTRODUCTION

4-2. This section of the manual has the Performance Tests and Calibration Procedures used to verify the 3468A's accuracy specifications, and to calibrate the multimeter to those specifications. A summary of the specifications to which the 3468A is tested and calibrated is listed in Table 4-1. The complete specifications are in Table 1-1. All tests and calibrations are made without removing any instrument covers.

4-3. Since Performance Tests are normally performed after calibration, the tests are included in the Calibration Procedures. The procedures are set up in such a way that the Performance Tests can be ignored, if so desired.

4-4. EQUIPMENT REQUIRED

4-5. All required test equipment for the Performance Tests and Calibration Procedures are listed in Table 4-2 (Recommended Test Equipment). The equipment used for the individual tests and the test procedures are also listed at the beginning of each test procedure. If any of the recommended equipment is not available, use substitute equipment. A short description of the required equipment and the critical specifications necessary to do the test and calibration procedures is in the following paragraphs. This information may be helpful in choosing substitute equipment.

4-6. DC Volts Test and Calibration

4-7. The DC Volts Test and Calibration (DC Volts Function) requires a very accurate Digital Voltmeter (like the 3456A) as the Standard. The Digital Voltmeter must be calibrated to its 24 hour dc volts specifications before calibrating and testing the 3468A (i.e. the 3468A is tested and calibrated within 24 hours after the Digital Voltmeter, which is used as the standard, has been calibrated). It is recommended that the Digital Voltmeter be calibrated in the same temperature environment and leave the Digital Voltmeter in the same temperature environment in which the 3468A is to be calibrated and tested (e.g. the 3468A's Reference Temperature, see Paragraph 4-39). In addition to the Digital Voltmeter, a DC Volts Standard is required to be used as a very stable voltage source. The following lists the required equipment and recommended models.

Table 4-1. Abbreviated Specifications Table

DC Volts Function (accuracy = ±(% of reading + number of counts))

Range	24 Hour Limits	90 Day Limits	1 Year Limits
.3V	0.005 + 4	0.009 + 5	0.02 + 5
3V	0.0035 + 2	0.007 + 2	0.018 + 2
30V	0.005 + 3	0.009 + 3	0.02 + 3
300V	0.0055 + 2	0.009 + 2	0.02 + 2

Current Function (accuracy = ±(% of reading + number of counts))

Range	90 Day Limits	1 Year Limits
3A < 1A	0.14 + 6	0.17 + 6
3A > 1A	1.0 + 30	1.0 + 30

AC Volts Function 1 Year Limits (accuracy = ±(% of reading + number of counts))

Frequency	.3V Range	3V,30V Range	300V Range
20Hz- 50Hz	1.14 + 163	1.14 + 102	1.18 + 102
50Hz-100Hz	0.46 + 163	0.46 + 103	0.50 + 102
100Hz- 20KHz	0.29 + 163	0.26 + 102	0.33 + 102
20KHz- 50KHz	0.56 + 247	0.41 + 180	0.55 + 180
50KHz-100KHz	1.74 + 882	1.05 + 825	1.26 + 825
100KHz-300KHz	N/A	10.1 + 3720 (30V Range only)	N/A

AC Current Function 1 Year Limits (accuracy = ±(% of reading + number of counts))

Frequency	.3A Range	Range
20 Hz 50 Hz	1.77 + 163	2.5 + 163
50 Hz 1KHz	1.1 + 163	1.8 + 163
1KHz 10KHz	1.0 + 163	1.7 + 163
10KHz 20KHz	1.14 + 163	1.84 + 163

Ohms Function (accuracy = ±(% of reading + number of counts))

Range	24 Hour Limits	90 Day Limits	1 Year Limits
300	0.0045 + 4	0.012 + 5	0.017 + 5
3K	0.0035 + 2	0.011 + 2	0.016 + 2
30K	0.0035 + 2	0.011 + 2	0.016 + 2
300K	0.0035 + 2	0.011 + 2	0.016 + 2
3M	0.0052 + 2	0.011 + 2	0.016 + 2
30M	0.036 + 2	0.066 + 2	0.078 + 2

Table 4-2. Recommended Test Equipment.

Instrument	Critical Specifications	Recommended Model	Use*
Digital Voltmeter	Range:300mV to 300V Accuracy: ±.004%(30V,300V) ±.005%(300mV,3V)	-hp- Model 3456A	PCT
DC Voltage Standard	Voltage:300mV to 300V Accuracy: ±.005%	Systron Donner Model M107	PCT
AC Calibrator	Frequency:20Hz to 300KHz Voltage:30mV to 300V Accuracy: ±.1% Voltage Stability: ±.02%	Fluke Model 5200A and Model 5215A	PCT
AC/DC Current Source	DC Current:1A Accuracy: ■.03% AC Current:100mA to 1A Frequency:1KHz to 5KHz Accuracy: ±.1%	Valhalla Model 2500	PCT
Resistance Standard		Guildline Model	
	Resistance:100 ohm Accuracy: ±.0005%	9330/100 or 9330A/100	PC
	Resistance:1K ohm Accuracy: ±.0005%	9330/1K or 9330A/1K	PC
	Resistance:10K ohm Accuracy: ±.001%	9330/10K or 9330A/10K	PC
	Resistance:100K ohm Accuracy: ±.001%	9330/100K or 9330/100K	PC
	Resistance:1M Accuracy: ±.01%	9330/1M	PC
	Resistance:10M Accuracy: ±.01%	9330/10M	PC
Desktop Computer	HP-IB Capability	hp Model 85, 9825,9826,9835,or 9845	CTO
Bus System Analyzer	HP-IB Control Capability	hp- Model 59401A	T
Oscilloscope	Bandwidth.DC to 100MHz	hp- Model 1740A	T
Signature Analyzer		-hp- Model 5004A	T

*P = Performance C = Calibration T = Troubleshooting O = Operator's Check

4-8. Digital Voltmeter. The recommended Digital Voltmeter is an -hp- Model 3456A. The critical requirements are as follows:

a. Required voltage range is from 300mV to 300V dc.

b. Accuracy and stability requirements in ■ 24 hour period are as follows:

±.004% for the 30V and 300V Ranges

±.005% for the 300mV and 3V Ranges

4-9. DC Volts Standard. The DC Volts Standard chosen is a Systron Donner Model M107 Precision Voltage Source. The critical requirements are as follows:

a. Output from 300mV to 300V dc.

b. Within .005% full scale accuracy.

c. Short term stability better than .0002% per hour.

4-10. AC Volts Test and Calibration

4-11. For the AC Volts Test and Calibration (AC Volts Function) use the Fluke Model 5200A/5215A AC Calibrator. If the calibrator is not available, use a substitute calibrator that meets the requirements listed following this paragraph. It is suggested to acquire the recommended calibrator with the HP-IB (IEEE 488) option 05 for future computerized Performance Test and Calibration.

a. Frequency Response: 20Hz to 100KHz (and 300KHz at 30V).

b. AC Volts Range: 300mV to 300V ac.

c. AC Volts Accuracy: ±.1%.

4-12. Ohms Test and Calibration

4-13. The 3468A's Ohms Function can be tested and calibrated in two different ways, at full scale or 1/3 scale. If the 3468A is to be tested and calibrated at full scale, use three each of the recommended standard resistors in series to form, 300ohm, 3Kohm, etc. If the 3468A is to be tested and calibrated at 1/3 scale, use only one each of the recommended standard resistors.

4-14. If the recommended resistors are not available, use substitutes that meet the critical requirements. If a substitute is not available, you may be able to use a calibrated decade resistor with settings that range from 300ohm to 30Mohm or 100ohm to 10Mohm. The correction factors on the decade resistor's calibration chart must be algebraically added to the 3468A reading, to achieve the required accuracy. The Standard Resistors and critical requirements are as follows:

a. **100 ohm, and 1K ohm Standard Resistors.** Use the Guildline Model 9330/100 or 9330A/100 for the 300 ohm Range, and Model 9330/1K or 9330A/1K for the 3K ohm Range. The accuracy requirement is ±.0005% or better.

b. **10K ohm and 100K ohm Standard Resistors.** Use the Guildline Model 9330/10K or 9330A/10K for the 30K ohm Range and Model 9330/100K or 9330A/100K for the 300K ohm Range. The accuracy requirement is ±.001% or better.

c. **1M ohm Standard Resistor.** Use the Guildline Model 9330/1M for the 3M ohm Range with ±.002% or better accuracy.

d. **10M ohm Standard Resistor.** Use the Guildline Model 9330/10M for the 30M ohm Range with ±.01% or better accuracy.

4-15. DC Current Test and Calibration

4-16. The DC Current Test and Calibration requires an AC-DC Current Calibrator as the current source, ■ Digital Voltmeter for the standard, and a DC Volts Standard for a stable voltage source. The following paragraphs have the required equipment and recommended models.

4-17. AC-DC Current Source. The Valhalla Model 2500 is the recommended AC-DC Current Source. The critical requirements are as follows:

a. Required current is 1A.

b. Required accuracy is ±.03%.

4-18. Digital Voltmeter. The recommended Digital Voltmeter is an -hp- Model 3456A. Refer to paragraph 4-8 for the critical requirements.

4-19. DC Volts Standard. The DC Volts Standard chosen is a Systron Donner Model M107 Precision Voltage Source. Refer to paragraph 4-9 for the critical requirements.

4-20. AC Current Test and Calibration

4-21. The AC Current Test and Calibration requires an AC-DC Current Calibrator as the current source and an AC Calibrator as the ac standard. The following paragraphs have the required equipment and recommended models.

4-22. AC-DC Current Source. The Valhalla Model 2500 is the recommended AC-DC Current Source. The critical requirements are as follows:

a. Required current is 100mA and 1A.

b. Required frequency response is: 1KHz and 5KHz

c. Required accuracy is ±.03%.

4-23. AC Calibrator. The recommended AC Calibrator is a Fluke Model 5200A/5215A. Refer to paragraph 4-11 for the critical requirements.

4-24. TEST CARDS

4-25. Performance Test Cards are provided at the end of this section and are to be used to record the 3468A's performance. It is recommended to fill out the cards and refer to them while doing the test. The test limits and set-up information are printed on the cards for easy reference. The cards can therefore be used as an abbreviated test procedure (if you are familiar with the test procedures). The cards can also be used as a permament record and may be reproduced without written permission from Hewlett-Packard.

4-26. CALIBRATION CYCLE

4-27. A periodic performance verification is required for the 3468A. This should be done as part of an incoming inspection test and at a 90 day or 1 year interval, depending on your environmental condition and accuracy requirements.

4-28. TEST FAILURE

4-29. If the 3468A fails any Performance Test, do the necessary calibration according to which test failed (e.g. do the DC Volts Calibration for ■ DC Volts Test failure). If only one range fails, calibrate only that range, otherwise calibrate the complete function (this is only true for the DC Volts and Ohms Functions). If the failure cannot be corrected by calibration, go to Section VII of this manual for servicing information.

4-30. INSTRUMENT SET-UP

4-31. Instrument set-up is specified in each test and calibration procedure.

4-32. INSTRUMENT SPECIFICATION

4-33. Specifications are the performance characteristics of the instrument which are certified. These specifications, listed in Table 1-1 and Table 4-1, are the performance standards or limits against which the 3468A can be tested. Table 1-1 also lists some supplemental characteristics of the 3468A and should be considered as additional information.

4-34. Any changes in the specifications due to manufacturing changes, design, or traceability to the National Bureau of Standards will be covered in a manual change supplement or revised manual. The specifications listed here supercede any previously published.

4-35. Specification Breakdown

4-36. The 3468A's specifications are grouped according to instrument function (AC Volts, DC Volts, etc.). Within each group are either one, two, or three main sets of specifications: the 24 hour, 90 day, and 1 year limits. The limits to which the 3468A conforms depend on when the instrument was last calibrated. They also depend on the limits to which the 3468A was certified and also on the instrument function. The 24 hour limits should only be used if the instrument was calibrated within the last 24 hours, otherwise, the 90 day or 1 year limits apply.

4-37. Each set of specifications includes an accuracy specification for each voltage, ohms, and current range. They are specified as a percentage of the reading and an add-on of a certain number of counts. For example, the 24 hour full scale DC Volts Function accuracy on the 30V Range (in the 5 Digit Display mode) is:

±.005% of reading + 3 counts

giving a full scale accuracy of ±.005% or (5 counts) plus 3 counts (or .003%), which is a total of 8 counts (or ±.008%). (This is only true at full scale and changes at 1/10 scale, see next paragraph.) If for example the 4 Digit Display mode is selected, the percentage is the same (.005%), but the number of counts is different and changes the total percentage to ±.015% (.005% plus 1 count in the 4 Digit mode is .01% which makes the total equal .015%).

4-38. The number of counts also changes the accuracy of the 3468A at 1/10 scale. For example, the percentage (same Function, Range, and Digit mode) at 1/10 scale is still .005% at 1/10 scale. However, the number of counts (3) is .03% at 1/10 scale. This gives a total of .035%, rather than .008% at full scale.

4-39. Temperature Coefficient (Reference Temperature)

4-40. The temperature in which the 3468A was last calibrated is called its Reference Temperature. To maintain the 3468A's specified accuracy, the multimeter must be operated within the specified range of that temperature (as shown in Table 1-1). If the 3468A is tested or operated outside the temperature range, the Temperature Coefficient (listed in Table 1-1) must be added to the instrument's specifications. It is recommended to calibrate the 3468A in the temperature in which it is to be tested and operated.

4-41. TEST CONSIDERATION

4-42. General

4-43. Because the 3468A is able to make highly accurate dc measurements, certain requirements have to be met. For example, the Digital Voltmeter used to test and calibrate the 3468A should be good enough so that its errors do not introduce any significant uncertainties in the Performance Test and Calibration. A Voltmeter which is 10 times better than the 3468A nearly eliminates the uncertainties. Since voltmeters (or even standards) with these accuracies are not readily available, use the recommended Digital Voltmeter. Make sure the voltmeter has been calibrated to its 24 hour specifications and used within 24 hours after calibration, before testing and calibrating the 3468A.

4-44. Ambiguous Region

4-45. Since the available test equipment is not an order of magnituide better than the 3468A, it is important to be aware of the uncertainties or "ambiguities". An example is in the next paragraph.

4-46. A hypothetical case is to check the 3468A's 3V full scale dc accuracy with a certain standard. The 3468A's 90 day specification is ±.01% with the standard's accuracy ideally ±.001% (ten times better). If the 3468A reading is "30.0033" (.011% high), the multimeter may or may not meet the 90 day limit (dependent on the standard's accuracy). If the standard is .001% high (30.0003V), the 3468A's actual reading is "30.0030" which is in the 90 day limit. If the standard output is right on, the 3468A reading is "30.0033" (its reading is high and out of tolerance). Although in both instances the standard is within its limits, it may show the 3468A to be in or out of its limits. This creates an Ambiguous Region, shown in Figure 4-1. The region gets bigger when the 3468A limits are tighter and/or the standard's specifications are less accurate. The best test is when you know your standard's actual limits.

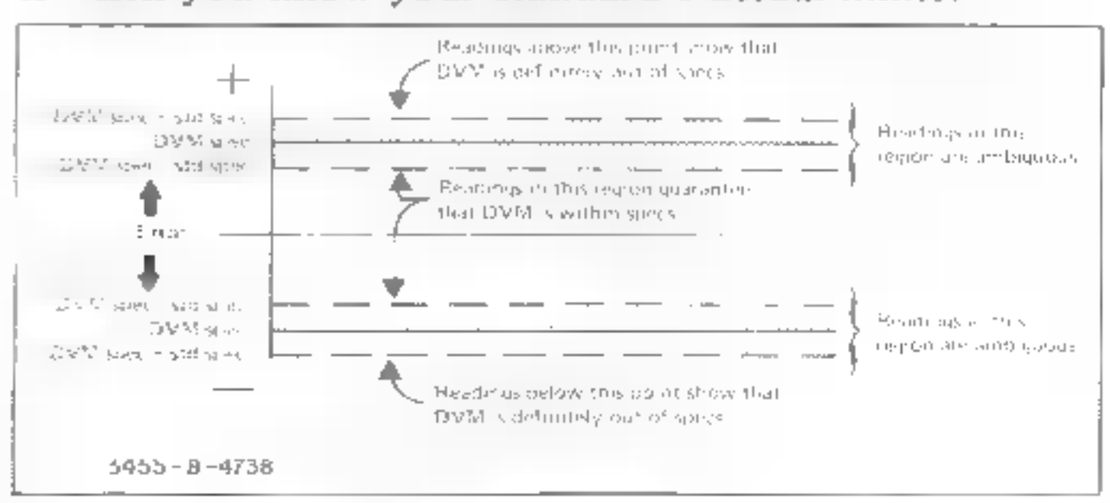


Figure 4-1. Ambiguous Regions

4-47. PERFORMANCE TEST

4-48. The Performance Test is separated into five main tests: DC Volts, DC Current, AC Volts, AC Current, and Ohms. Each step in the tests and the tests themselves should be done in the order they are given, starting with the DC Volts Test. Allow at least a 1 hour warm-up time. If the 3468A has been on for less time, inaccuracies can result. The Performance Test is separated into the following tests.

a. DC Volts Test - paragraph 4-49.

b. DC Current Test - paragraph 4-54.

c. AC Volts Test - paragraph 4-59.

d. AC Current Test - paragraph 4-64.

e. Ohms Test - paragraph 4-69.

4-49. DC Volts Test

4-50. The DC Volts Test limits are printed on the DC Volts Test Card and in Table 4-3. The instrument set-up information is also printed on the test card. Each step on the test card corresponds to a step in the test procedure. Because of this, each step number on the test card is shown in parenthesis (e.g., Step #1.) in the procedure.

4-51. Unless otherwise specified, all test signals are applied to the 3468A's HI and LO INPUT Terminals.

4-52. Equipment Required. The following is the required test equipment for the DC Volts Test.

Digital Voltmeter (-hp- Model 3456A)
DC Volts Standard (Systron Donner Model M107)

4-53. Test Procedure. After the 3468A has been warmed up for at least one hour, do the following:

a. (Step #1.) Reset the 3468A by pressing the blue Shift button and then the SGL/TRIG (TEST/RESET) button.

NOTE

Resetting the 3468A, automatically places the instrument into the DC Volts Function, Autorange, Internal Trigger, and 5 Digits Displayed.

b. (Step #2.) Short the 3468A's INPUT Terminals. The instrument should now be on the .3V Range.

c. Record the displayed reading on the Test Card and make sure the reading is within the limits shown on the Test Card and in Table 4-3.

d. (Step #3, 4, and 5.) Set the 3468A to the 3V, 30V, and 300V Range by pressing the Uprange button once for each range. Record and make sure the reading on each range is within the specified limits. If any readings in this step or step c are out of the specified limits, go to the DC Volts Calibration Procedure in paragraph 4-86.

e. (Step #6.) Remove the short from the 3468A's INPUT Terminals and set the multimeter to the .3V Range.

f. Set the DC Volts Standard for zero volts output. Set the Digital Voltmeter to the DC Volts Function and Autorange.

g. Connect the 3468A to the Digital Voltmeter and DC Volts Standard, as shown in Figure 4-2. Use the Digital Voltmeter as the standard and the DC Standard

Table 4-3. DC Volts Test Limits

3468A Input	3468A Range	3468A Set Up	24 Hour Limits high	24 Hour Limits low	90 Day Limits high	90 Day Limits low	1 Year Limits high	1 Year Limits low
Short	.3V	DCV	+000004V	−000004V	+.000005V	−.000005V	+.000005V	−.000005V
Short	3V		+0.00002V	−0.00002V	+0.00002V	−0.00002V	+0.00002V	−0.00002V
Short	30V		+00.0003V	−00.0003V	+00.0003V	−00.0003V	+00.0003V	−00.0003V
Short	300V		+000.002V	−000.002V	+000.002V	−000.002V	+000.002V	−000.002V
300mV	.3V		+.300019V	+.299981V	+.300032V	+.299968V	+.300065V	+.299935V
300mV	3V		+0.30003V	+0.29997V	+0.30004V	+0.29996V	+0.30007V	+0.29993V
+1V	3V		+1.00006V	+0.99994V	+1.00009V	+0.99991V	+1.00020V	+0.99980V
−1V	3V		−1.00006V	−0.99994V	−1.00009V	−0.99991V	−1.00020V	−0.99980V
−3V	3V		−3.00013V	−2.99987V	−3.00023V	−2.99977V	−3.00056V	−2.99942V
+3V	3V		+3.00013	+2.99987V	+3.00023V	+2.99977V	+3.00056V	+2.99944V
+3V	3V	AZ Off	+3.00016	+2.99984V	+3.00026V	+2.99974V	+3.00059V	+2.99941V
+3V	3V	AZ On, 4 Digit	+3.0002V	+2.9998V	+3.0003V	+2.9997V	+3.0006V	+2.9994V
+3V	3V	3 Digit	+3.001V	+2.999V	+3.001V	+2.999V	+3.002V	+2.998V
+3V	30V	[illegible] Digit	+03.0005V	+02.9995V	+03.0006V	+02.9994V	+03.0009V	+02.9991V
+10V	30V		+10.0008V	+09.9992V	+10.0012V	+09.9988V	+10.0023V	+09.9977V
+30V	30V		+30.0018V	+29.9982V	+30.0030V	+29.9970V	+30.0063V	+29.9937V
+30V	30V	AZ Off	+30.0029V	+29.9971V	+30.0041V	+29.9995V	+30.0074V	+29.9926V
+300V	300V	AZ On	+300.019V	+299.981V	+300.029V	+299.971V	+300.062V	+299.938V

as the power supply. An example on how the Digital Voltmater and DC Volts Standard checks the 3468A accuracy using the multimeter's 3V Range, is as follows:

1. Set the 3468A to the 3V Range.

2. Set the DC Volts Standard for an output of +3V.

3. Note the reading on the Digital Voltmeter. If the reading is not exactly +3V, adjust the DC Volts Standard until the reading is exactly +3V, as displayed by the Digital Voltmeter. This reading is then the standard voltage used to check the 3468A reading.

4. Make sure the 3468A reading is within its specified limits. Record the reading on the Test Card.

NOTE

Always uprange the 3468A before upranging the DC Volts Standard and always downrange the DC Volts Standard before downranging the 3468A.

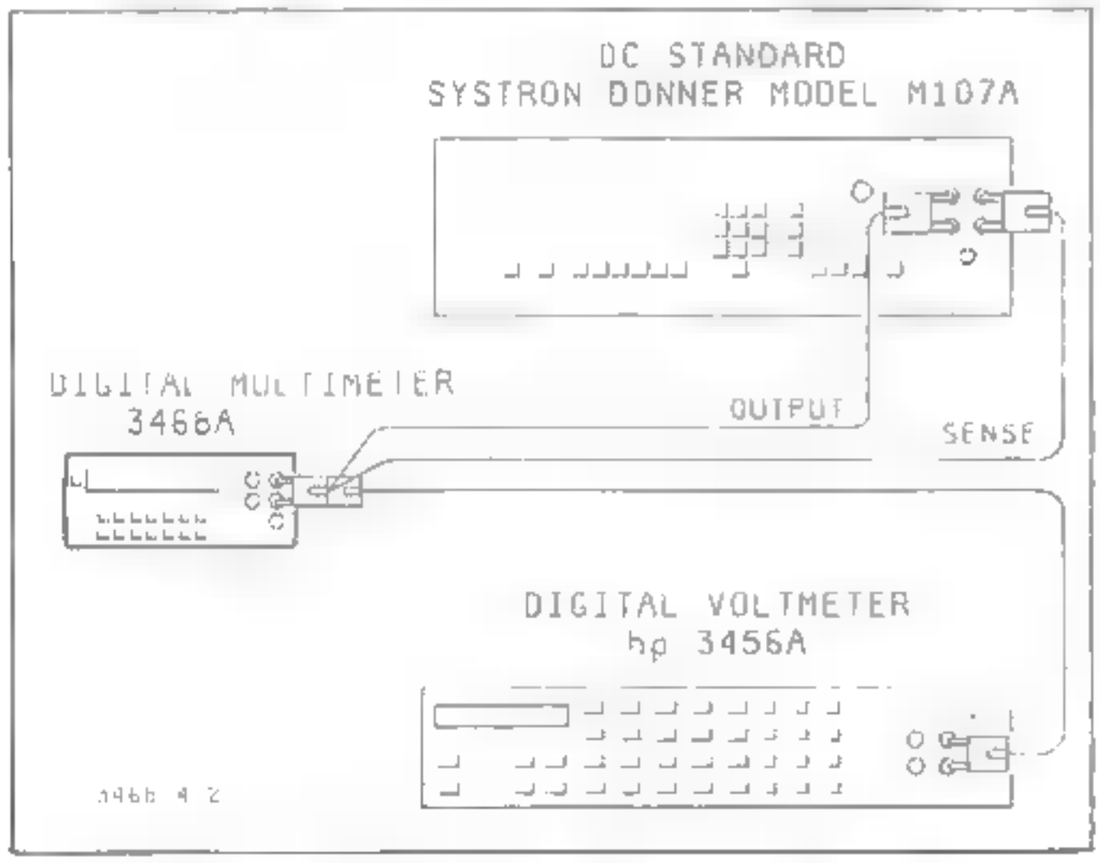


Figure 4-2. DC Volts Accuracy Test

h. Check the multimeter's .3V Range full scale accuracy by setting the DC Volts Standard for an accurate output (as displayed on the Digital Voltmeter) of 300mV. Check the multimeter's reading and make sure it is within the specified limits.

i. (Step #7.) Set the 3468A to the 3V Range and set the DC Volts Standard for an accurate output of +300mV. Check and record the reading.

j. (Step #8.) Set the DC Volts Standard for a +1V output. Check and record the reading.

k. (Step #9.) Apply -1V to the 3468A by reversing the input leads. (Leave the leads in that position for the next step.) Check and record the reading.

l. (Step #10.) Set the DC Volts Standard for ■ 3V output (-3V input to the 3468A). Check and record the readings.

m. (Step #11.) Apply +3V to the 3468A by reversing the input leads. (Leave the leads in that position for the steps that follow.) Check and record the readings.

n. (Step #12.) With +3V applied to the 3468A, turn Autozero off by pressing the blue Shift button and then the INT/TRIG (AUTO/ZERO) button. Check and record the reading.

o. (Step #13.) Turn Autozero on by pressing the blue Shift button and then the INT/TRIG (AUTO/ZERO) button.

p. (Step #14.) With +3V applied to the 3468A, select the multimeter's 4 Digit Display mode by pressing the blue Shift button and then the Uprange (4) button. Check and record the reading.

q. (Step #15.) Select the 3468A's 3 Digit Display mode by pressing the blue Shift button and then the AUTO/MAN (3) button. Check and record the reading.

r. (Step #16.) Select the 3468A's 5 Digit Display mode by pressing the blue Shift button and then the Downrange (5) button.

s. (Step #17, 18, and 19.) Set the 3468A to the 30V Range. Check the multimeter's 1/10, 1/3, and full scale accuracy by setting the DC Volts Standard for accurate outputs of +3V, +10V, and +30V, respectively. Check and record the readings. Leave the +30V connected to the 3468A.

t. (Step #20.) With +30V applied to the 3468A, turn Autozero off by pressing the blue Shift button and then the INT/TRIG (AUTO/ZERO) button. Check and record the reading.

u. (Step #21.) Turn Autozero on by pressing the blue Shift button and then the INT/TRIG (AUTO/ZERO) button.

v. (Step #22.) Set the 3468A to the 300V Range. Check the full scale accuracy by setting the DC Volts Standard for an accurate output of +300V. Check and record the readings.

w. (Step #23.) Turn the DC Volts Standard's output off. Disconnect the DC Volts Standard and Digital Voltmeter from the 3468A.

x. (Step #24.) The DC Common Mode Rejection Test is next. Do the following:

1. Set the 3468A to the .3V Range.

2. Connect a 1K ohm resistor (-hp- Part No. 0698-1021) between the 3468A's HI and LO INPUT Terminals.

3. Note the 3468A's reading.

4. With the DC Volts Standard's output off, connect the standard to the 3468A as shown in Figure 4-3.

5. Set the DC Volts Standard for an output of 400V and then turn its output on. Check and make sure the 3468A's reading is within .040mV of the reading noted in step 3.

y. Turn the DC Volts Standard's output off and then disconnect it from the 3468A. This completes the DC Volts Test. If any test fails, try calibrating the instrument (go to paragraph 4-86). If the test still fails, go to Section VII of this manual for troubleshooting.

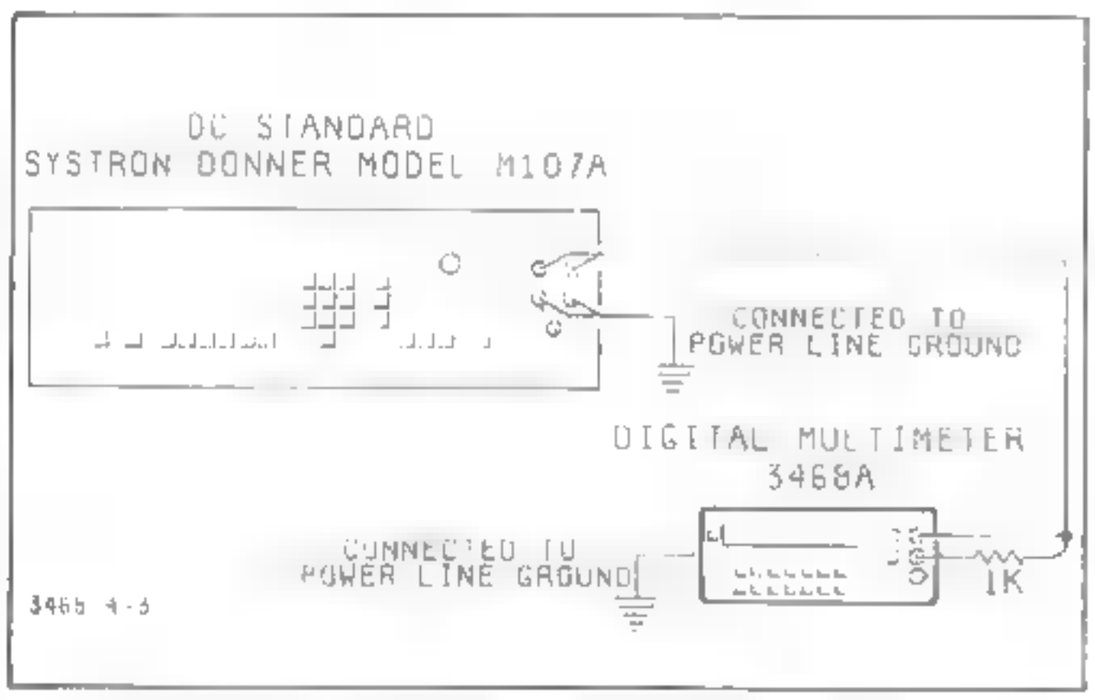


Figure 4-3. DC Common Mode Rejection Test

4-54. DC Current Test

4-55. The DC Current Test limits are printed on the DC Current Test Card and in Table 4-4. Each step on the test card also corresponds to a step in the procedure with each step number shown in parenthesis in the procedure.

4-56. Unless otherwise noted, all test signals are applied to the 3468A's A (Amps) amd LO INPUT Terminals.

4-57. Equipment Required. The following is the required test equipment for the DC Current Test.

Digital Voltmeter (-hp- Model 3456A)
DC Volts Standard (Systron Donner Model M107)
AC-DC Current Calibrator (Valhalla Model 2500)

4-58. Test Procedure. Make sure the DC Volts Performance Test has been completed, before doing the DC Current Test. Also make sure the 3468A has been warmed up for at least one hour, then do the following:

a. (Step #1.) Reset the 3468A by pressing the blue Shift button and then the SGL/TRIG (TEST/RESET) button.

b. (Step #2.) Set the 3468A to the DC Current Function and short the multimeter's A (Amps) Terminal to the LO INPUT Terminal.

c. Record the displayed reading on the Test Card and make sure the reading is within the limits shown on the Test Card and Table 4-4.

d. (Step #3.) Remove the short from the A and LO INPUT Terminals.

e. Set the DC Volts Standard for a +1V output.

f. Set the Digital Voltmeter to the DC Volts Function, 1V Range, and 6 Digit Display mode.

g. Set the AC-DC Current Calibrator to the 1A Range.

h. Connect the DC Volts Standard and Digital Voltmeter to the AC-DC Current Calibrator as shown in Figure 4-4.

i. Connect the AC-DC Current Calibrator to the 3468A as shown in Figure 4-3.

j. Make sure the reading on the Digital Voltmeter is exactly +1V. Readjust the DC Volts Standard, if necessary.

k. Check and record the reading on the 3468A.

l. Remove the DC Volts Standard and Digital Voltmeter from the AC-DC Current Calibrator. Remove the current calibrator from the 3468A. This completes the DC Current Test. If any test fails, try

Table 4-4. DC Current Test Limits

3468A Input	Range	Set Up	90 Day Limits high	90 Day Limits low	1 Year Limits high	1 Year Limits low
Short	3A	DCI	+0.0006A	−0.00006A	+0.00006A	−0.00006A
+1A	3A		+1.00146A	+0.99854A	+1.00176A	+0.99824A

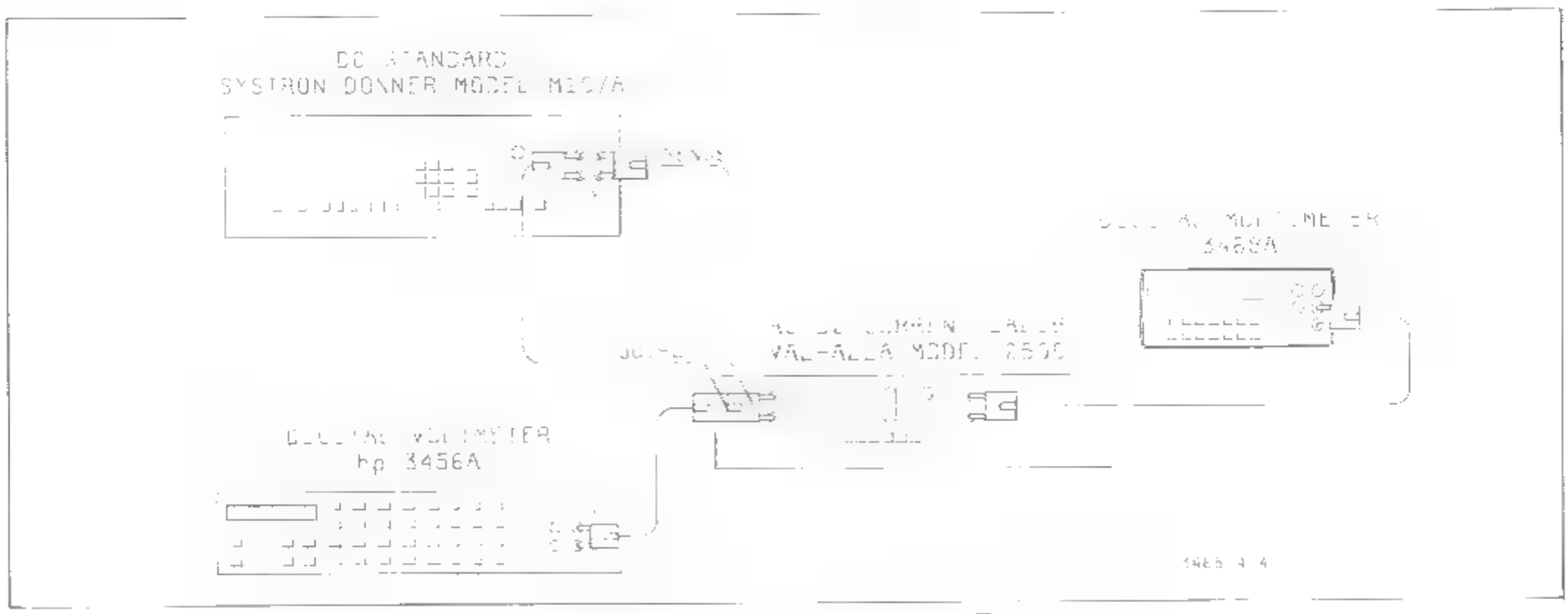


Figure 4-4. DC Current Accuracy Test

calibrating the instrument (go to paragraph 4-90). If the test still fails, go to this manual's Section VII for troubleshooting.

4-59. AC Volts Test

4-60. The AC Volts Test limits are printed on the AC Volts Test Card and in Table 4-5. Each step on the test card also corresponds to a step in the procedure with each step number shown in parenthesis in the procedure.

4-61. All test signals are applied to the 3468A's HI and LO INPUT Terminals.

Table 4-5. AC Volts Test Limits

3468A Input	3468A Range	3468A Set Up	1 Year Limits high	1 Year Limits low
.028V,20KHz	.3V	ACV	.028244V	.027756V
0.28V,20KHz	.3V		.280975V	.279025V
0.28V,20KHz	3V		0.28175V	0.27825V
1.5V,20KHz	3V		1.50492V	1.49508V
2.8V,20KHz	3V		2.80830V	2.79170V
2.8V,20KHz	30V		02.8175V	02.7825V
28V,20KHz	30V		28.0830V	27.7170V
28V,20KHz	300V		028.194V	027.806V
280V,20KHz	300V		281.026V	278.974V
0.28V,50KHz	300mV		.281815V	.278185V
2.8V,50KHz	3V		2.81328V	2.78672V
28V,50KHz	30V		28.1328V	27.8672V
280V,50KHz	300V		281.720V	278.280V
0.28V,100KHz	300mV		.285754V	.274246V
0.28V,100KHz	3V		0.29119V	0.26881V
2.8V,100KHz	3V		2.83765V	2.76235V
15V,100KHz	30V		15.2400V	14.7600V
28V,100KHz	30V		28.3765V	27.6235V
280V,100KHz	300V		284.353V	275.647V
25V,300KHz	30V		27.8970V	22.1030V
2.8V,50Hz	3V		2.81391V	2.78609V
2.8V,20Hz	3V		2.83294V	2.76706V

4-62. Equipment Required. The required test equipment for the AC Volts Test is the AC Calibrator (Fluke Model 5200A, 5215A Option 05).

4-63. Test Procedure. Make sure the DC Volts Performance Tests have been completed before doing the AC Volts Test. Also make sure the 3468A has been warmed up for at least one hour, then do the following:

a. (Step #1.) Reset the 3468A by pressing the blue Shift buttton and then the SGL/TRIG (TEST/RESET) button.

b. (Step #2.) Set the 3468A to the AC Volts Function.

c. Set the AC Calibrator for a .028V at 20KHz output. Connect the output of the calibrator to the INPUT Terminals of the 3468A.

d. (Step #3 and 4.) Set the 3468A to the .3V Range. Check the 1/10 and full scale reading of the range by applying .028V at 20KHz and .28V at 20KHz, respectively. Check the readings and make sure they are within the specified limits shown in Table 4-5 and the AC Volts Performance Test Card. Record the readings.

e. (Step #5, 6, and 7.) Set the 3468A to the 3V Range. Check the 1/10, 1/2, and full scale accuracy of the range by applying 0.28V at 20KHz, 1.5V at 20KHz, and 2.8V at 20KHz, respectively. Check and record the readings.

f. (Step #8 and 9.) Set the 3468A to the 30V Range. Check the 1/10 and full scale accuracy of the range by applying 2.8V at 20KHz and 28V at 20KHz, respectively. Check and record the readings.

g. (Step #10 and 11.) Set the 3468A to the 300V Range. Check the 1/10 and full scale accuracy of the range by applying 28V at 20KHz and 280V at 20KHz, respectively. Check and record the readings.

h. (Step #12, 13, 14, and 15.) Check the full scale accuracy of the .3V, 3V, 30V, and 300V Range by applying .28V at 50KHz, 2.8V at 50KHz, 28V at 50KHz, and 280V at 50KHz, respectively. Check and record the readings.

i. (Step #16.) Set the 3468A to the .3V Range. Check the full scale accuracy of the range by applying .28V at 100Hz. Check and record the reading.

j. (Step #17 and 18.) Set the 3468A to the 3V Range. Check the 1/10 and full scale accuracy of the range by applying .28V at 100KHz and 2.8V at 100KHz, respectively. Check and record the readings.

k. (Step #19 and 20.) Set the 3468A to the 30V Range. Check the 1/2 and full scale accuracy of the range by applying 15V at 100KHz and 28V at 100KHz, respectively. Check and record the readings.

l. (Step #21.) Set the 3468A to the 300V Range. Check the full scale accuracy of the range by applying 280V at 100KHz. Check and record the reading.

m. (Step #22.) Set the 3468A to the 30V Range. Check the full scale accuracy of the range by applying 25V at 300KHz. Check and record the reading.

n. (Step #23 and 24.) Set the 3468A to the 3V Range. Check the full scale accuracy of the range by applying 2.8V at 50Hz and then 2.8V at 20Hz.

o. Disconnect the AC Calibrator from the 3468A. This completes the AC Volts Test. If any test fails, try calibrating the instrument (go to paragraph 4-94). If the test still fails, go to this manual's Section VII for troubleshooting.

4-64. AC Current Test

4-65. The AC Current Test limits are printed on the AC Current Test Card and in Table 4-6. Each step on the test card also corresponds to a step in the procedure with each step number shown in parenthesis in the procedure.

4-66. All test signals are applied to the 3468A's A (Amps) and LO INPUT Terminals.

4-67. Equipment Required. The following is the required test equipment for the AC Current Test.

AC Calibrator (Fluke Model 5200A Option 05).
AC Calibrator (Valhalla Model 2500).

Table 4-6. AC Current Test Limits

3468A Input	3468A Range	3468A Set Up	1 Year Limits high	1 Year Limits low
.01A,5KHz	.3A	ACI	.010263A	.009737A
0.1A 5KHz	.3A		.101163A	.098837A
1A,5KHz	1A		1.01863A	0.98137A

4-68. Test Procedure. Make sure the AC Volts Performance Test has been completed, before doing the AC Current Test. Also make sure the 3468A has been warmed up for at least one hour, then do the following:

a. (Step #1.) Reset the 3468A by pressing the blue Shift button and then the SGL/TRIG (TEST/RESET) button.

b. (Step #2.) Set the 3468A to the AC Current Function and the .3A Range.

c. (Step #3.) Set the AC Calibrator for a 1V at 5KHz output.

d. Set the AC-DC Current Calibrator to the 10mA Range.

e. Connect the AC Calibrator to the AC-DC Current Calibrator as shown in Figure 4-5.

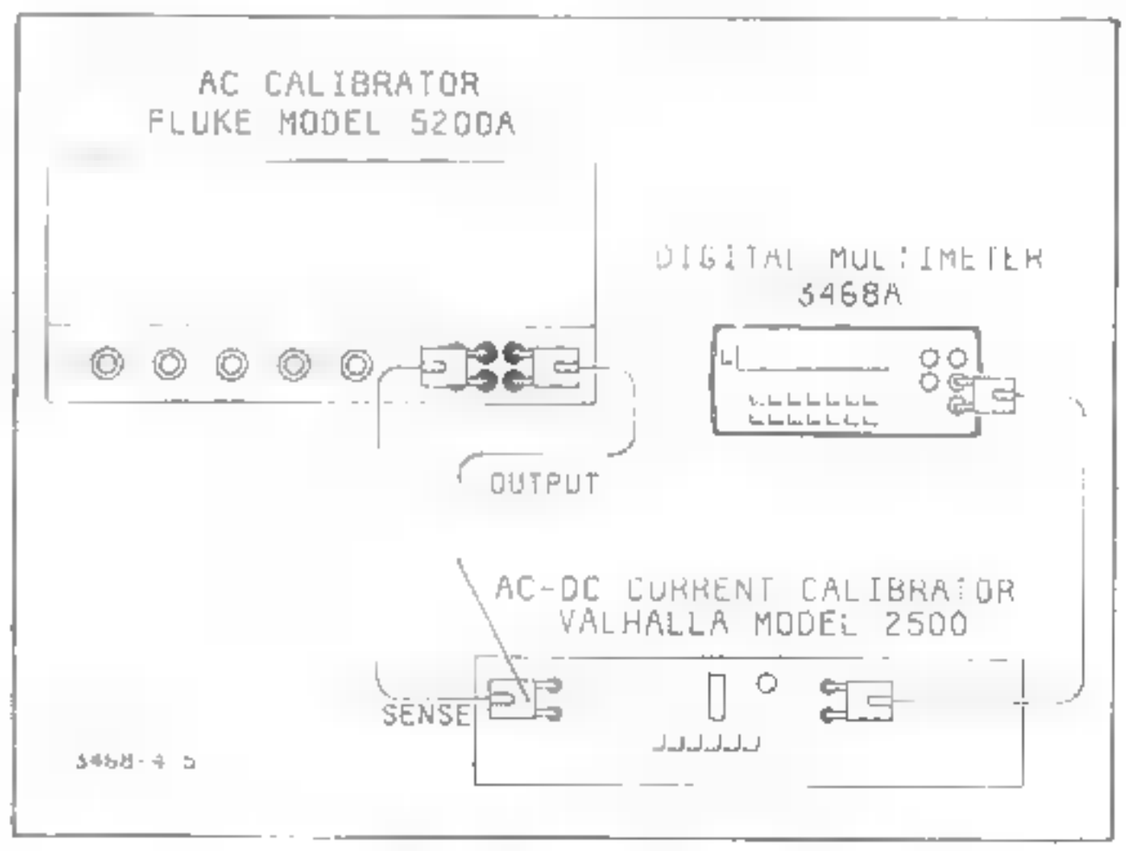


Figure 4-5. AC Current Accuracy Test

f. Connect the 3468A to the AC-DC Current Calibrator as shown in Figure 4-5.

g. Check and record the 3468A's reading.

h. (Step #4.) Set the AC-DC Current Calibrator to the 100mA Range. Check and record the 3468A's reading.

i. (Step #5.) Set the 3468A and the AC-DC Current Calibrator to the 1A Range. Check and record the 3468A's reading.

j. Remove the AC Calibrator from the AC-DC Current Calibrator. Remove the current calibrator from the 3468A. This completes the AC Current Test. If any test fails, try calibrating the instrument (go to paragraph 4-99). If the test still fails, go to this manual's Section VII for troubleshooting.

4-69. Ohms Test

4-70. The Ohms Test should only be performed in the ohms function in which the 3468A was last calibrated. If, for example, the 3468A was last calibrated in the 4-Wire Ohms Function, perform the Ohms Test in the 4-Wire Ohms Function. If the 3468A was last calibrated in the 2-Wire Ohms Function, perform the Ohms Test in the 2-Wire Ohms Function. In addition, the same test connections or leads used to calibrate the 3468A in the 2-Wire Ohms Function must also be used when testing the multimeter in that function. This is because the impedance of the test leads is cancelled out when the multimeter is calibrated (in the 2-Wire Ohms Function). A different set of test leads can have different impedances which show up as an ohms test error.

4-71. The Ohms Function of the 3468A can be tested using either full scale or 1/3 scale inputs (e.g. 3K ohm or 1K ohm resistors to check the 3K ohm Range). Because of this, both test limits are given in Table 4-7 and on the Ohms Performance Test Card. The test step numbers (on the Test Card) shown in parenthesis are for the 1/3 scale tests. When testing the 3468A, make sure the test leads used to connect the standard resistor to the 3468A's INPUT Terminals are as short [redacted] possible. This is to prevent the leads from picking up any noise, which could give an invalid reading.

4-72. If the 3468A is to be tested in the 2-Wire Ohms Function, all test resistors are applied to the 3468A's INPUT Terminals. If the 4-Wire Ohms Function is to be tested, short the INPUT Terminals or connect the test resistors as shown in Figure 4-6 and Figure 4-7, respectively.

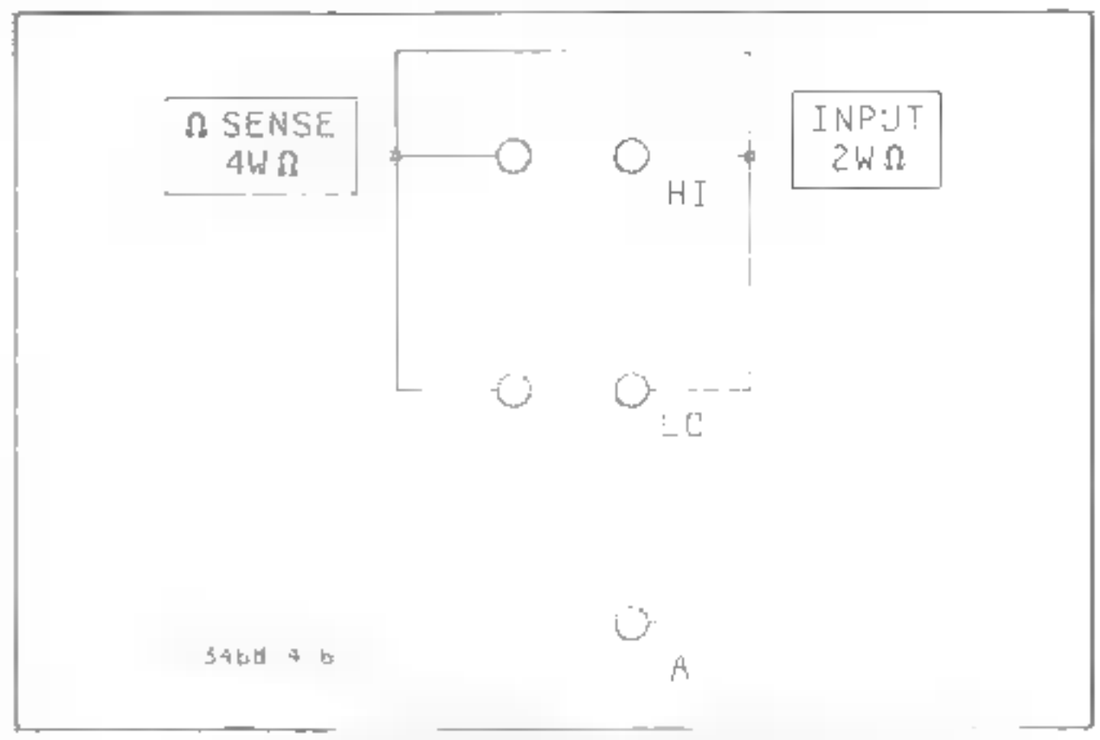


Figure 4-6. 4-Wire Ohms Test Connection

4-73. The Ohms Test limits are printed on the Ohms Test Card and in Table 4-7. Each step on the test card corresponds to a step in the procedure with each step number shown in parenthesis in the procedure.

4-74. Equipment Required. The following is the required test equipment for the Ohms Test.

Standard Resistors:

100 ohm ±.0005%; (Guildline Model 9330/100 or 9330A/100)
1K ohm ±.0005%; (Guildline Model 9330/1K or 9330A/1K)
10K ohm ±.001%; (Guildline Model 9330/10K or 9330A/10K)

Table 4-7. Ohms Test Limits

3468A Input	[redacted] Range	3468A Set Up	24 Hour Limits high	24 Hour Limits low	90 Day Limits high	90 Day Limits low	1 Year Limits high	1 Year Limits low
Short	300	Ohms	000.004	000.000	000.004	000.000	00.0041	00.0000
Short	3K		0.00002K	0.00000K	0.00002K	0.00000K	0.0041	00.0000
Short	30K		00.0002K	00.0000K	00.0002K	00.0000K	000.005	000.000
Short	300K		000.002K	000.000K	000.002K	000.000K	00.0002K	00.0000K
Short	3M		0.00002M	0.00000M	0.00002M	0.00000M	000.002K	000.000K
Short	30M		00.0002M	00.0000M	00.0002M	00.0000M	0.00002M	0.00000M
300	300		300.012	299.988	300.041	299.959	300.056	299.944
(100)			100.004	099.996	100.017	099.983	100.022	099.978
3K	3K		3.00014K	2.99986K	3.00035K	2.99965K	3.00050K	2.99950K
(1K)			1.00006K	0.99994K	1.00013K	0.99987K	1.00018K	0.99982K
30K	30K		30.0014K	29.9986K	30.0035K	29.9965K	30.0050K	29.9950K
(10K)			10.0006K	09.9994K	10.0013K	09.9987K	10.0018K	09.9982K
300K	300K		300.014K	299.986K	300.035K	299.965K	300.050K	299.950K
(100K)			100.006K	099.994K	100.013K	099.987K	100.018K	099.982K
3M	3M		3.00017M	2.99983M	3.00035M	2.99965M	3.00050M	2.99950M
(1M)			1.00007M	0.99993M	1.00013M	0.99987M	1.00018M	0.99982M
30M	30M		30.0110M	29.9890M	30.0200M	29.9800M	30.0236M	29.9764M
(10M)			10.0038M	09.9962M	10.0068M	09.9932M	10.0080M	09.9920M

100K ohm ±.001%; (Guildline Model 9330/100K or 9330A/100K)
1M ohm ±.002%; (Guildline Model 9330/1M)
10M ohm ±.01%; (Guildline Model 9330/10M)

4-75. Test Procedure. Make sure the 3468A's DC Volts Tests have been done, before doing the Ohms Test. Also make sure the 3468A has been warmed up for at least one hour, then do the following:

a. (Step #1.) Reset the 3468A by pressing the blue Shift button and then the SGL/TRIG (TEST/RESET) button.

b. (Step #2.) Set the 3468A to the desired Ohms Function (see paragraph 4-70). If the 2-Wire Ohms Function is to be tested, short the INPUT Terminals. If the 4-Wire Ohms Function is to be tested, short the SENSE Terminals and the INPUT Terminals, as shown in Figure 4-6. Check the reading on the 3468A's display and record the reading on the Test Card.

c. (Step #3, 4, 5, 6, and 7.) Set the 3468A to the 3KΩ, 30KΩ, 300KΩ, 3MΩ, and 30MΩ Range by pressing the Uprange button once for each range. Record and make sure the reading on each range are within the specified limits. If any readings in this step and step b are out of the specified limits, go to the Ohms Calibration Procedure in paragraph 4-103.

d. (step #8.) Remove the short from the 3468A's INPUT Terminals and set the multimeter to the 300Ω Range.

e. Connect either a 300Ω or 100Ω Standard Resistor to the INPUT Terminals (refer to paragraph 4-71 to determine the resistor value). If the 3468A is to be tested in the 2-Wire Ohms Function, connect the resistor to the INPUT Terminals. If the test is to be done in the 4-Wire Ohms Function, connect the resistor as shown in Figure 4-7.

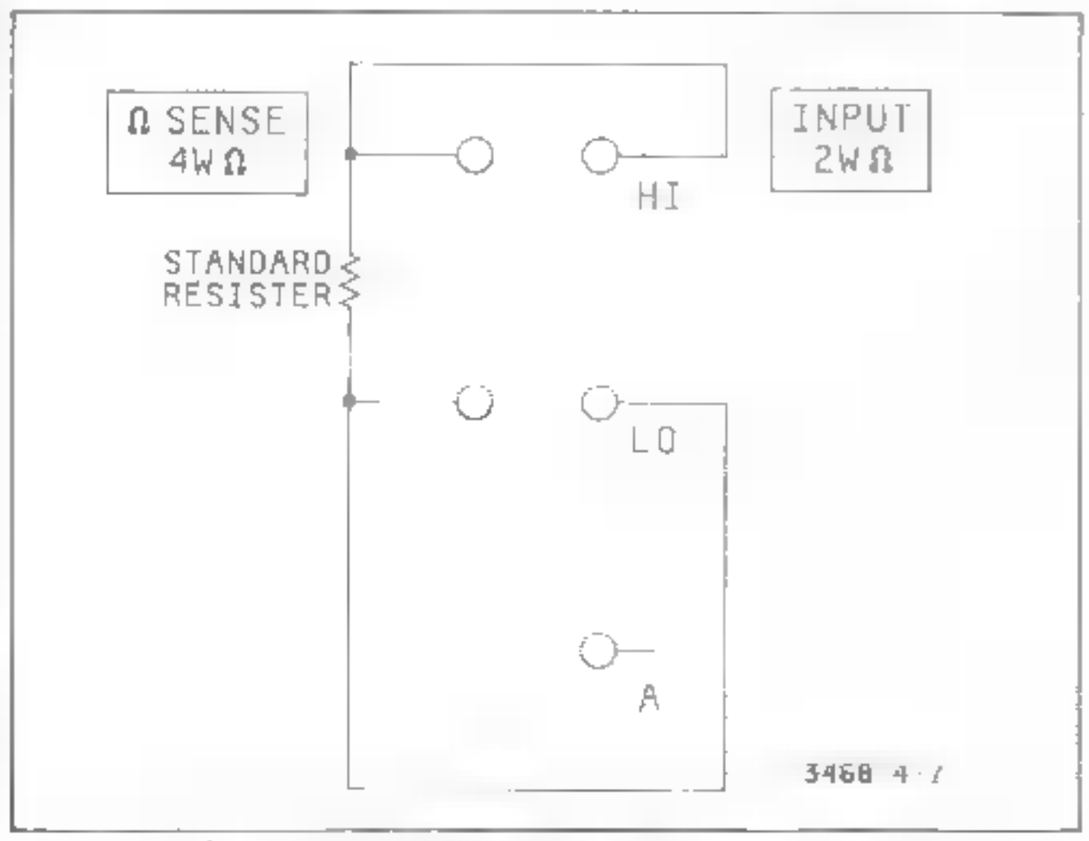


Figure 4-7. 4-Wire Ohms Connections

f. Check and record the reading.

g. (Step #9 through 13.) Check the 3468A's 3KΩ, 30KΩ, 300KΩ, 3MΩ, and 30MΩ Ranges by connecting the following standard resistors to the multimeter's input: 3KΩ (or 1KΩ), 30KΩ (or 10KΩ), 300KΩ (or 100KΩ), 3MΩ (or 1MΩ), and 30MΩ (or 10MΩ), respectively. Check and record the readings.

h. Remove the Standard Resistors from the 3468A. This completes the Ohms Test. If any test fails, try calibrating the instrument (go to paragraph 4-103). If the test still fails, go to this manual's Section VII for troubleshooting.

4-76. COMBINED CALIBRATION AND PERFORMANCE TESTS

4-77. General

4-78. The following paragraphs have the 3468A's Combined Calibration Procedures and Peformance Tests. The Perfomance Tests are included in the procedures since they are normally performed after calibration. The procedures are set up in such ■ way that the Performance Tests can be ignored, if so desired.

4-79. Since the 3468A has no internal adjustments, the multimeter is calibrated electronically. A known good calibration source is applied to the 3468A's INPUT Terminals which is used to calibrate the multimeter. Ten readings are then taken and the entered value of the calibration source is compared with the average value of the ten readings. A Calibration Constant is then calculated and stored into the calibration RAM. The constant is used to calculate the correct readings.

4-80. Calibrating the 3468A

4-81. The 3468A is calibrated by first applying a zero input to the instrument (i.e., INPUT terminals shorted) and then applying a full scale input (or in some cases, a 1/3 scale input). When the zero input is applied, the 3468A takes a reading and stores the resultant zero constant in its calibration RAM. When the full scale input is applied, the 3468A again takes a reading and stores the resultant gain constant into the RAM. This constant has to be within .955 to 1.045 or the 3468A will display an error message. The following is an example on how calibration is performed. The 3V Range in the DC Volts function is chosen for the example. It is suggested to go through the example before going to the calibration procedures to gain an understanding on how the 3468A is calibrated.

a. Set the 3468A to the DC Volts Function and the 3V Range. Make sure the instrument is not in Autorange.

b. Short the instrument's INPUT Terminals (zero input).

c. Set the rear panel CAL ENABLE Switch to the calibration enable position (the down position, as shown on the rear panel).

d. Set the multimeter to the Single Trigger mode by pressing the SGL/TRIG button.

e. A zero reading, or an approximate zero reading, should now be displayed. In addition to the reading, "C:" is also displayed to the right of the reading (e.g. "+0.00002C:").

f. Press the blue Shift button and then the LOCAL (CAL) button.

g. The 3468A then makes a measurement and decides what type of input is applied to the instrument. Since it is a zero input, the 3468A should now display +0.00000? VDC. (The displayed "C:" is replaced by a "?".)

h. Press the SGL/TRIG (Single Trigger) button only once.

i. The 3468A will display "+0.00000? CAL" for about five seconds and then "ZERO DONE" for about two seconds. The zero calibration constant for the DC Volts Function in the 3V Range is now stored in the instrument's calibration RAM.

j. Remove the short from the 3468A and apply an accurate +3V to the INPUT Terminals. For best accuracy, use a +3V calibration source of which its exact value is known (e.g. +3.00015V, +2.99985V, etc.). This voltage must be within the range of +2.99000V to +3.01000V.

k. Press the blue Shift button and then the LOCAL (CAL) button.

l. The 3468A again makes a measurement, and this time decides that the applied input is +3V. The display should now show "+3.00000? VDC".

m. If the exact value of the calibration source is unknown, but the source is accurate enough to calibrate the multimeter, continue with step o.

n. If the exact value of the calibration source is known, the 3468A can be calibrated to that value. This is done by setting the display to the known value. The thing to remember is that the display can show no more than ±1000 counts of the absolute value. The calibration is performed as follows:

1. After the CAL button is pressed, the 3468A will display "+3.00000? VDC". The reading on the display can now be changed using the Uprange and Downrange buttons until the applied value and displayed value agree with each other.

2. If the source is above +3V, press the 3468A's Uprange button until the displayed reading agrees with the source. Pressing the button once will increment the reading by one count. To continue increasing the displayed reading, press the button repeatedly. For example, if the source is +3.00015V, press the Uprange button 15 times, until "+3.00015? VDC" is displayed. If the button was pressed too long and the displayed reading is too high, press the Downrange button until the values agree.

3. If the source is below +3V, press the 3468A's Downrange button until the displayed reading agrees with the source. This operation is the same as using the Uprange button, except the displayed reading is decreased rather than increased. For example, if the source is +2.99985V, press the Downrange button until "+2.99985? VDC" is displayed.

o. Press the SGL/TRIG button once.

p. The 3468A will display "+3.00000? CAL" for about five seconds, as it measures the calibration source and compares it to the number previously displayed (step l or n). If the calibration source were outside the limits of 2.99000 to 3.01000 volts, the "INV CAL SIG" error message will be displayed (refer to paragraph 4-83c). If the source is within the limits, ■ "GAIN CONSTANT" is automatically calculated and stored in internal memory. All subsequent dc voltage measurements will be corrected by this gain constant. Consequently, they will be no more accurate than the accuracy of the calibration source itself.

q. The message "GAIN DONE" will be displayed for about two seconds when the calibration process is completed.

r. If there is no more calibration to be performed, set the 3468A's CAL ENABLE switch to the up position. The instrument is now ready for use.

NOTE

Make sure the CAL ENABLE switch at the rear panel is in the "up" position, before cycling power on the instrument.

4-82. Calibration Messages

4-83. When calibrating the 3468A, certain messages may be displayed by the multimeter. The following steps lists the messages and also gives information on what to do if a certain message is displayed.

a. ENABLE CAL - This message shows that the rear panel CAL ENABLE switch is not in the enable position (the switch is in the up position) when attempting to calibrate the multimeter. Make sure the switch is in the correct position, when attempting to calibrate.

b. INV CAL F&R - This message is displayed if the calibration constants cannot be calculated in the present function or range. It is most likely caused if the 3468A is set to an invalid range or function.

c. INV CAL SIG - This shows that the 3468A cannot calibrate to the applied input signal. This message is displayed if the applied signal causes the 3468A to calculate a gain constant which is out of range (.955 to 1.045) or an offset constant greater than 10,000 counts. Make sure the correct signal is applied for the selected function and range.

d. INV CAL ZERO - The 3468A displays this message if the zero calibration constant is invalid when attempting to calibrate the gain. Make sure the 3468A has been calibrated by a correct zero signal.

e. INV CAL NUM - This message shows that the number in the display is not acceptable for calibration. Make sure the number is within ±1000 counts of 300000 (or 100000 for 1/3 scale calibration) and also make sure no zero calibration is attempted with display not at zero, when calibrating over the HP-IL.

f. CAL RAM BAD - This shows that the Calibration RAM did accept data which was written to it, but the data was incorrect. Redo the calibration.

4-84. Calibration Procedures

4-85. Each step in the procedures and the procedures themselves must be done in the order they are given. Each procedure has two parts, Calibration and Performance Test. The performance test part can be ignored, if so desired. Since, after calibration, the 3468A will meet its full scale 24 Hour limits, the performance test for full scale (or in some cases 1/3 scale) and zero inputs are not included. This is because the 3468A is normally calibrated using full scale (or 1/3 scale) and zero inputs. The Calibration and Performance Test Procedures are separated as follows:

a. DC Volts Calibration and Test- paragraph 4-86.
b. DC Current Calibration and Test - paragraph 4-90.
c. AC Volts Calibration and Test - paragraph 4-94.
d. AC Current Calibration and Test - paragraph 4-99.
e. Ohms Calibration and Test - paragraph 4-103.

4-86. DC Volts Calibration and Test

4-87. Refer to Table 4-8 for the DC Volts Calibration Signals, Performance Test Signals, and Performance Test Limits. Each step in the table is shown in parenthesis in the procedure. Unless otherwise noted, the calibration and test signals are applied to the 3468A's INPUT Terminals.

4-88. Equipment Required. The following is the required test equipment for the DC Volts Calibration and Test.

Table 4-8. DC Volts Calibration and Test

Step#	3468A Input	3468A Range	3468A Set Up	Test Limits high	Test Limits low
1	Short	.3V	DCV	Cal.	Cal.
2	+300mV	.3V		Cal.	Cal.
3	Short	3V		Cal.	Cal.
4	+3V	3V		Cal.	Cal.
5	+300mV	3V		+30003V	+0.29997V
6	+1V	3V		+1.00006V	+0.99994V
7	−1V	3V		−1.00006V	−0.99994V
8	−3V	3V		−3.00013V	−2.99987V
9	+3V	3V	AZ Off	+3.00016	+2.99984V
10	+3V	3V	AZ On,		
11			4 Digit	+3.0002V	+2.9998V
12	+3V	3V	3 Digit	+3.001V	+2.999V
13	Short	30V	5 Digit	Cal.	Cal.
14	+30V	30V		Cal.	Cal.
15	+3V	30V		+03.0005V	+02.9995V
16	+10V	30V		+10.0008V	+09.9992V
17	+30V	30V	AZ Off	+30.0029V	+29.9971V
18	Short	300V	AZ On	Cal.	Cal.
19	+300V	300V		Cal.	Cal.

Digital Voltmeter (-hp- Model 3456A)
DC Volts Standard (Systron Donner Model M107)

4-89. Calibration and Test Procedure. After the 3468A has been warmed up for at least one hour, do the following:

a. Reset the 3468A by pressing the blue Shift button and then the SGL/TRIG (TEST/RESET) button.

NOTE

Resetting the 3468A automatically places the instrument into the DC Volts Function, Autorange, Internal Trigger, and 5 Digits Displayed Mode.

b. Set the rear panel CAL ENABLE Switch to the calibration enable position (the switch is in the down position, as shown on the rear panel).

c. Set the multimeter to the Single Trigger Mode by pressing the SGL/TRIG button.

d. (Step #1.) Short the 3468A's INPUT Terminals. Set the instrument to the .3V Range (take out of Autorange).

e. Press the blue Shift button and then the LOCAL (CAL) button.

f. Press the SGL/TRIG (Single Trigger) button only once and then remove the short from the Input Terminals.

g. Set the DC Volts Standard for zero volts output.

h. (Step #2.) Connect the 3468A to the Digital Voltmeter and DC Volts Standard, as shown in Figure 4-2. Use the Digital Voltmeter (DVM) as the standard and the DC Volts Standard as a stable power supply.

i. Set the DC Volts Standard's output for +300mV and note the reading on the Digital Voltmeter.

j. Press the blue Shift button and then the LOCAL (CAL) button.

k. Using the 3468A's Uprange and/or Downrange buttons, adjust the reading on the multimeter until it agrees with the reading on the Digital Voltmeter.

l. Press the SGL/TRIG (Single Trigger) button once.

m. (Step #3 and 4.) Remove the Digital Voltmeter and the DC Volts Standard from the 3468A. Short the 3468A's INPUT Terminals and set the instrument to the 3V Range.

n. Calibrate the 3V Range (applying zero and full scale inputs) by using the procedure in steps e to l. The only exception is that the DC Volts Standard is set for an output (in step i) of +3V instead of +300mV.

o. If no performance checks for the 3V range are to be made, remove the DC Volts Standard and Digital Voltmeter from the 3468A. Continue with step q.

p. If the performance checks for the 3V Range are to be made, do the following:

1. Set the 3468A to the Internal Trigger Mode by pressing the INT/TRIG button.

2. (Step #5.) Set the DC Volts Standard for a +300mV output.

3. Using the Digital Voltmeter as the standard, check and make sure the 3468A reading is within the specified limits shown in Table 4-8.

4. (Step #6.) Set the DC Volts Standard for a +1V output. Check the reading.

5. (Step #7.) Apply -1V to the 3468A by reversing the input leads. (Leave the leads in that position for the next step.) Check the reading on the multimeter (per Table 4-8).

6. (Step #8.) Apply -3V to the 3468A by setting the DC Volts Standard for a 3V output. Check the reading.

7. (Step #9.) Apply +3V to the 3468A by reversing the input leads. Check the reading.

8. With +3V applied to the 3468A, turn Autozero off by pressing the blue Shift button and then the INT/TRIG (AUTO/ZERO) button. Check the reading.

9. (Step #10.) Turn Autozero on by pressing the blue Shift button and then the INT/TRIG (AUTO/ZERO) button.

10. (Step #11.) With +3V still applied, select the multimeter's 4 Digit Display mode by pressing the blue Shift button and then the Uprange (4) button. Check the reading.

11. (Step #12.) Select the 3468A's 3 Digit Display by pressing the blue Shift button and then the AUTO/MAN (3) button. Check the reading.

12. (Step #13.) Select the 3468A's 5 Digit Display by pressing the blue Shift button and then the Downrange (5) button.

13. Remove the DC Volts Standard and Digital Voltmeter from the 3468A and set the multimeter back to the Single Trigger Mode (press the SGL/TRIG button).

q. (Step #13 and 14.) Short the 3468A's INPUT Terminals. Set the instrument to the 30V Range.

r. Calibrate the 30V Range (applying zero and full scale inputs) by using the procedure in steps e to l. The only exception is that the DC Volts Standard is set for an output (in step i) of +30V instead of +300mV.

s. If no performance checks for the 30V range are to be made, remove the DC Volts Standard and Digital Voltmeter from the 3468A. Continue with step u.

t. If the performance checks for the 30V Range are to be made, do the following:

1. Set the 3468A to the Internal Trigger Mode by pressing the INT/TRIG button.

2. (Step #15.) Set the DC Volts Standard for a +3V output.

3. Using the Digital Voltmeter as the standard, check and make sure the 3468A reading is within the specified limits shown in Table 4-8.

4. (Step #16.) Set the DC Volts Standard for a +10V output. Check the reading on the multimeter.

5. (Step #17.) Set the DC Volts Standard for a +30V output.

6. With +30V applied to the 3468A, turn Autozero off by pressing the blue Shift button and then the INT/TRIG (AUTO/ZERO) button. Check and make sure the reading is within 11 counts of the +30V calibration source.

7. (Step #18.) Turn Autozero on by pressing the blue Shift button and then the INT/TRIG (AUTO/ZERO) button.

8. Remove the DC Standard and Digital Voltmeter from the 3468A and set the multimeter

back to the Single Trigger Mode (press the SGL/TRIG button).

u. (Step #18 and 19.) Short the 3468A's INPUT Terminals. Set the instrument to the 300V Range.

v. Calibrate the 300V Range (applying zero and full scale inputs) by using the procedure in steps ■ to l. The only exception is that the DC Volts Standard is set for an output (in step i) of +300V instead of +300mV.

w. If no DC Common Mode Rejection Test is to be made, turn the output of the DC Volts Standard off and remove it and the Digital Voltmeter from the 3468A.

x. If DC Common Mode Rejection Test is to be made, do the following:

1. Set the 3468A to the .3V Range.

2. Connect a 1K ohm resistor (-hp- Part No. 0698-1021) between the 3468A's HI and LO INPUT Terminals.

3. Note the 3468A's reading.

4. With the DC Volts Standard's output off, connect the standard to the 3468A as shown in Figure 4-3.

5. Set the DC Volts Standard for 400V output and then turn its output on. Check and make sure the 3468A's reading is within .040mV of the reading noted in step 3.

6. Turn the DC Standard's output off and then disconnect it from the 3468A. This completes the DC Volts Test (and Calibration). If any test fails, go to Section VII of this manual for troubleshooting.

4-90. DC Current Calibration and Test

4-91. Refer to Table 4-9 for the DC Current Calibration Signals, Performance Test Signals, and Performance Test Limits. Each step in the table is shown in parenthesis in the procedure. All test Signals are applied to the 3468A's A (Amps) and LO INPUT Terminals.

Table 4-9. DC Current Calibration and Test

Step#	3468A Input	3468A Range	3468A Set Up	Test Limits high	Test Limits low
I	Short	3A	DCI	Cal.	Cal.
■	+1A	3A		Cal.	Cal.

4-92. Equipment Required. The following is the required test equipment for the DC Current Calibration and Test.

Digital Voltmeter (-hp- Model 3456A)
DC Volts Standard (Systron Donner Model M107)
AC-DC Current Calibrator (Valhalla Model 2500)

4-93. Calibration and Test Procedure. Do the following:

a. Reset the 3468A by pressing the blue Shift button and then the SGL/TRIG (TEST/RESET) button.

b. Make sure the rear panel CAL ENABLE Switch is set to the calibration enable position (the switch is in the down position).

c. (Step #1.) Set the 3468A to the DC Current Function and the 3A Range.

d. Set the multimeter to the Single Trigger Mode by pressing the SGL/TRIG button.

e. Make sure no connections are made between the A and LO INPUT Terminals.

f. Press the blue Shift button and then the LOCAL (CAL) button.

g. Press SGL/TRIG button once.

h. Remove the short from the 3468A.

i. Set the DC Volts Standard for a +1V output.

j. Set the Digital Voltmeter to the DC Volts Function, 1V Range, and 6 Digit Display Mode.

k. Set the AC-DC Current Calibrator to the 1A Range.

l. Connect the DC Volts Standard and Digital Voltmeter to the AC-DC Current Calibrator as shown in Figure 4-4.

m. (Step #2.) Calibrate the 3468A by doing the procedure in steps f and g.

n. Since the performance checks are the same as the calibration points, the checks are not required. Remove the DC Volts Standard and Digital Voltmeter from the AC-DC Current Calibrator and remove the calibrator from the 3468A. This completes the 3468A's DC Current Calibration and Test.

4-94. AC Volts Calibration and Test

4-95. The AC Volts Function is calibrated using only one calibration source, 3V at 1KHz. With the 3V ac signal applied, the 3468A determines the gain constants by taking a measurement in the 3V Range and 30V Range. The measurement in the 3V Range is a full-scale measurement and the 30V Range is a 1/10 scale measurement. The ranges are automatically selected by the multimeter.

4-96. Refer to Table 4-10 for the AC Volts Calibration Signals, Performance Test Signals, and Performance

Test Limits. Each step in the table is shown in parenthesis in the procedure. All test signals are applied to the 3468A's INPUT Terminals.

4-97. Equipment Required. The required test equipment for the AC Volts Calibration and Test is an AC Calibrator (Fluke Model 5200A/5215A option 05).

Table 4-10. AC Volts Calibration and Test

Step#	3468A Input	3468A Range	3468A Set Up	Test Limits high	Test Limits low
1	3V,1KHz	3V	ACV	Cal.	Cal.
2	.028V,20KHz	.3V		.028244V	.027756V
3	0.28V,20KHz	.3V		.280975V	.279025V
4	0.28V,20KHz	3V		0.28175V	0.27825V
5	1.5V,20KHz	3V		1.50492V	1.49508V
6	2.8V,20KHz	3V		2.80830V	2.79170V
7	2.8V,20KHz	30V		02.8175V	02.7825V
8	28V,20KHz	30V		28.0830V	27.7170V
9	28V,20KHz	300V		028.194V	027.806V
10	280V,20KHz	300V		281.026V	278.026V
11	0.28V,50KHz	300mV		.081815V	.278185V
12	2.8V,50KHz	3V		2.81328V	2.71328V
13	28V,50KHz	30V		28.1328V	27.8672V
14	280V,50KHz	300V		281.720V	278.280V
15	0.28V,100KHz	300mV		.285754V	.274246V
16	0.28V,100KHz	3V		0.29119V	0.26881V
17	2.8V,100KHz	3V		2.83765V	2.76235V
18	15V,100KHz	30V		15.2400V	14.7600V
19	28V,100KHz	30V		28.3765V	27.6235V
20	280V,100KHz	300V		284.353V	275.647V
21	25V,300KHz	30V		27.8970V	22.1030V
22	2.8V,50Hz	3V		2.81391V	2.78609V
23	2.8V,20Hz	3V		2.83294V	2.76706V

4-98. Calibration and Test Procedure. Do the following:

a. Reset the 3468A by pressing the blue Shift button and then the SGL/TRIG (TEST/RESET) button.

b. Make sure the rear panel CAL ENABLE Switch is set to the calibration enable position (the switch is in the rear position).

c. (Step #1.) Set the 3468A to the AC Volts Function and the 3V Range.

d. Set the multimeter to the Single Trigger Mode by pressing the SGL/TRIG button.

e. Set the AC Calibrator for a 3V at 1KHz output and connect it to the 3468A's INPUT Terminals.

f. Press the blue Shift button and then the LOCAL (CAL) button.

g. Using the 3468A's Uprange and/or Downrange buttons, adjust the reading on the multimeter until it agrees with the output value of the AC Calibrator (if the output value is known).

h. Press the SGL/TRIG button once.

i. If no performance checks are to be made, remove the AC Calibrator from the 3468A. AC Volts Calibration is now completed.

j. (Step #2.) If the performance checks are to be made, set the AC Calibrator for a .028V at 20KHz output. Set the 3468A to the .3V Range. Check the reading on the multimeter and make sure it is within the specified limits (per Table 4-10).

k. (Step #3.) Do the same as in the previous step by applying .28V at 20KHz to the multimeter.

l. (Step #4, 5, and 6.) Set the 3468A to the 3V Range. Check the 1/10, 1/2, and full scale accuracy of the range by applying .28V at 20KHz, 1.5V at 20KHz, and 2.8V at 20KHz, respectively. Check the readings.

m. (Step #7 and 8.) Set the 3468A to the 30V Range. Check the 1/10 and full scale accuracy of the range by applying 2.8V at 20KHz and 28V at 20KHz, respectively. Check the readings.

n. (Step #9 and 10.) Set the 3468A to the 300V Range. Check the 1/10 and full scale accuracy of the range by applying 28V at 20KHz and 280V at 20KHz, respectively. Check the readings.

o. (Step #11, 12, 13, and 14.) Check the full scale accuracy of the .3V, 3V, 30V, and 300V Range by applying .28V at 50KHz, 2.8V at 50KHz, 28V at 50KHz, and 280V at 50KHz, respectively.

p. (Step #15.) Set the 3468A to the .3V Range. Check the full scale accuracy of the range by applying .28V at 100KHz. Check the reading.

q. (Step #16 and 17.) Set the 3468A to the 3V Range. Check the 1/10 and full scale accuracy of the range by applying .28V at 100KHz and 2.8V at 100KHz, respectively. Check the readings.

r. (Step #18 and 19.) Set the 3468A to the 30V Range. Check the 1/2 and full scale accuracy of the range by applying 15V at 100KHz and 28V at 100KHz, respectively. Check the readings.

s. (Step #20.) Set the 3468A to the 300V Range. Check the full scale accuracy of the range by applying 280V at 100KHz. Check the reading.

t. (Step #21.) Set the 3468A to the 30V Range. Check the full scale accuracy of the range by applying 25V at 300KHz. Check the reading.

u. (Step #22 and 23.) Set the 3468A to the 3V Range. Check the full scale accuracy of the range by applying 2.8V at 50Hz and then 2.8V at 20Hz.

v. Disconnect the AC Calibrator from the 3468A. This completes the AC Volts Calibration and Test.

4-99. AC Current Calibration and Test (Optional)

4-100. Since the DC Current and AC Volts Calibration has been performed, no AC Current Calibration is necessary. If there is any doubt about the accuracy of the AC Current Function, the function can be checked using the Optional AC Current Calibration and Test Procedures in the following paragraphs. Refer to Table 4-11 for the Performance Test Signals and Performance Test Limits. Each step in the table is shown in parenthesis in the procedure. All test signals are applied to the A (amps) and LO INPUT Terminals.

Table 4-11. AC Current Calibration and Test

Step#	3468A Input	3468A Range	3468A Set Up	Test Limits high	Test Limits low
1	0.1A,1KHz	.3A		.010263A	.009737A
2	0.1A,5KHz	.3A		.101163A	.098837A
3	1A,5KHz	1A		1.01863A	0.98137A

4-101. Equipment Required. The following is the required test equipment for the AC Current Calibration and Test.

AC Calibrator (Fluke Model 5200A Option 05)
AC-DC Current Calibrator (Valhalla Model 2500)

4-102. Calibration and Test Procedure. Do the following:

a. Reset the 3468A by pressing the blue Shift button and then the SGL/TRIG (TEST/RESET) button.

b. (Step #1.) Set the 3468A to the AC Current Function and the .3A Range.

c. Set the AC Calibrator for a 1V at 5KHz output.

d. Set the AC-DC Current Calibrator to the 10mA Range.

e. Connect the AC Calibrator to the AC-DC Current Calibrator as shown in Figure 4-5.

f. Check the 3468A's reading.

g. (Step #2.) Set the AC-DC Current Calibrator to the 100mA Range. Check the 3468A's reading.

h. (Step #3.) Set the 3468A to the 3A Range. Set the AC-DC Current Calibrator to the 1A Range. Check the 3468A's reading.

i. Remove the 3468A and the AC Calibrator from the AC-DC Current Calibrator. This completes the AC Current Calibration and Test.

4-103. Ohms Calibration and Test

4-104. The 3468A's Ohms Function can be calibrated in either the 2-Wire or 4-Wire Ohms Function. It cannot be calibrated in both. Make sure the multimeter is calibrated in the function which will be used. If the 3468A is to be calibrated in the 2-Wire Ohms Function, connect the Standard Resistors to the 3468A's INPUT Terminals. If the 3468A is to be calibrated in the 4-Wire Ohms Function, connect the Standard Resistors as shown in Figure 4-7.

4-105. Refer to Table 4-12 for the Ohms Calibration Signals, Performance Test Signals, and Performance Test Limits. Each step in the table is shown in parenthesis in the procedure. All test signals are applied to the INPUT Terminals. The 3468A can be calibrated either at full scale or 1/3 scale. Both the full scale and 1/3 input values are given in Table 4-12 and the Performance Test Card. The 1/3 scale input values are given in parenthesis.

Table 4-12. Ohms Calibration and Test

Step#	3468A Input	3468A Range	3478A Set Up	Test Limits high	Test Limits low
1	Short	300	Ohms	Cal.	Cal.
2	300	300		Cal.	Cal.
(2)	(100)	300		Cal.	Cal.
3	Short	3K		Cal.	Cal.
4	3K	3K		Cal.	Cal.
(4)	(1K)	3K		Cal.	Cal.
5	Short	30K		Cal.	Cal.
6	30K	30K		Cal.	Cal.
(6)	(10K)	30K		Cal.	Cal.
7	Short	300K		Cal.	Cal.
8	300K	300K		Cal.	Cal.
(8)	(100K)	300K		Cal.	Cal.
9	Short	3M		Cal.	Cal.
10	3M	3M		Cal.	Cal.
(10)	(1M)	3M		Cal.	Cal.
11	Short	30M		Cal.	Cal.
12	30M	30M		Cal.	Cal.
(12)	(10M)	30M		Cal.	Cal.

4-106. Equipment Required. The following is the required test equipment for the Ohms Calibration and Test. If the 3468A is to be calibrated at 1/3 scale, use one of the following recommended standard resistors. If the 3468A is to be calibrated at full scale, use three each of the recommended standard resistors to form 3K ohm, 30K ohms, etc.

100 ohm ±.0005%; (Guildline Model 9330/100 or 9330A/100)
1K ohm ±.0005%; (Guildline Model 9330/1K or 9330A/1K)
10K ohm ±.001%; (Guildline Model 9330/10K or 9330A/10K)
100K ohm ±.001%; (Guildline Model 9330/100K or 9330A/100K)
1M ohm ±.002%; (Guildline Model 9330/1M)
10M ohm ±.01%; (Guildline Model 9330/10M)

4-107. Calibration and Test Procedure. Do the following:

a. Reset the 3468A by pressing the blue Shift button and then the SGL/TRIG (TEST/RESET) button.

b. Make sure the rear panel CAL ENABLE Switch is set to the calibration enable position (the switch is in the down position).

c. (Step #1.) Set the 3468A to the Ohms Function and the 300Ω Range.

d. Set the multimeter to the Single Trigger Mode by pressing the SGL/TRIG button.

e. Short the 3468A's INPUT Terminals. If the 4-Wire Ohms Function is to be calibrated, short the terminals as shown in Figure 4-6.

f. Press the blue Shift button and then the LOCAL (CAL) button.

g. Press the SGL/TRIG button once.

h. (Step #2.) Connect the 300Ω or 100Ω Standard Resistor to the 3468A's INPUT Terminal. If the 4-Wire Ohms Function is to be calibrated, connect the resistor as shown in Figure 4-7.

i. Press the blue Shift button and then the LOCAL (CAL) button.

j. Press the SGL/TRIG button once.

k. (Step #3 and 4.) Set the 3468A to the 3KΩ Range and calibrate the range using zero and full scale (or 1/3 scale) inputs. Use the same procedures in steps d through i, except use a 3KΩ (or 1KΩ) resistor instead of a 300Ω (or 100Ω) resistor.

l. (Step #5 and 6.) Set the 3468A to the 30KΩ Range and calibrate the range using zero and full scale (or 1/3 scale) inputs. Use the same procedures in steps d through i, except use a 30KΩ (or 10KΩ) resistor instead of a 300Ω (or 100Ω) resistor.

m. (Step #7 and 8.) Set the 3468A to the 300KΩ Range and calibrate the range using zero and full scale (or 1/3 scale) inputs. Use the same procedures in steps d through i, except use a 300KΩ (or 100KΩ) resistor instead of a 300Ω (or 100Ω) resistor.

n. (Step #9 and 10.) Set the 3468A to the 3MΩ Range and calibrate the range using zero and full scale (or 1/3 scale) inputs. Use the same procedures in steps d through i, except use a 3MΩ (or 1MΩ) resistor instead of a 300Ω (or 100Ω) resistor.

o. (Step #11 and 12.) Set the 3468A to the 30MΩ Range and calibrate the range using zero and full scale (or 1/3 scale) inputs. Use the same procedures in steps d through i, except use a 30MΩ (or 10MΩ) resistor instead of a 300Ω (or 100Ω) resistor.

p. Since the points checked in the Performance Test are the same points that where calibrated, no Performance Test is required. Set the rear panel CAL ENABLE switch to the up position. This completes the Ohms Calibration and Test.

4-108. REMOTE CALIBRATION

4-109. General

4-110. The 3468A can be remotely calibrated using the HP-IL (Hewlett-Packard Interface Loop). In remote calibration, a computer is used to set-up the 3468A to the required range, function, and calibration mode instead of doing it from the instrument's front panel.

4-111. Remote calibration uses the same test equipment, including hook up to the 3468A, as is used in local calibration. In addition, both remote and local calibration procedures are basically the same in that zero scale and full or ⅓ scale calibration signals are used. It is therefore helpful to know how to calibrate 3468A locally. Read the calibration procedures in paragraphs 4-80 to 4-107 before attempting to calibrate remotely.

4-112. The following paragraph has an example on how to remotely calibrate the 3468A. In the example, the 3468A is calibrated on the 3V by remotely sending the appropriate program codes. Then the value of the calibration signal is remotely sent to the 3468A's display. Once this is done, the program code to calibrate the instrument is sent. The example shows how to send the program codes using an -hp- Model 85A Desktop Computer and an -hp- Model 41CV Handheld Programmable Calculator. It is assumed that you know how to program the 3468A using the 85A or 41CV. For information on programming the 3468A, refer to the 3468A Operator's Manual or Section III of this manual.

4-113. Remote Calibration Example

4-114. Connect the 3468A to the HP-IL and make sure it is the first instrument in the loop after the HP-IL controller (i.e., 85A or 41CV). Then turn the controller off and on. This insures that the 3468A HP-IL address is "1".

4-115. With the 3468A turned on, set the CAL ENABLE switch (switch 8) on the instrument's rear panel to down. A "C" should now appear on the right end of the numbers in the 3468A's display indicating that calibration is enabled. Calibrate the instrument on the 3V Range in the DC Volts Function by doing the following steps. Each step is separated into two sections with the first section showing how to calibrate using the 85A and the other using the 41CV. The 3468A is calibrated by applying zero volts and 3V or 1V calibration signals. Do the following.

a. The 3468A is set to Remote and Listen and then program codes "F1R2N5Z1T1" are sent to the instrument. This sets the 3468A to the DC Volts Function (F1), 3V

Range (R2), 5 ½ Digit Displayed (N5), Autozero On (Z1), and Internal Trigger (T1).

1. Model 85A.

   OUTPUT 901 ;"F1R2N5Z1T1"

The "OUTPUT 901" statement sets the 3468A to Remote and Listen, and "F1R2N5Z1T1" are the program codes sent to the instrument.

2. Model 41CV.

Step#	Action
1.	Press XEQ button
2.	Press ALPHA button
3.	Enter "REMOTE" from keyboard
4.	Press ALPHA button
5.	Press ALPHA BUTTON
6.	Enter "F1R2N6Z1T1" from keyboard
7.	Press ALPHA button
8.	Press XEQ button
9.	Press ALPHA button
10.	Enter "OUTA" from keyboard
11.	Press ALPHA button

Steps 1 through 4 set the 3468A to Remote and Listen. Steps 5 through 7 enter program codes "F1R2N5Z1T1" into the ALPHA register. Steps 8 through 11 output the ALPHA register which sends the program codes to the 3468A.

b. After the 3468A is set up to the desired function and range, apply the zero volts calibration signal to the instrument. This is done by shorting the HI and LO INPUT Terminals. Once this is performed, the value in the 3468A display has to be set to the value of the calibration signal (i.e., OV). This is done by sending program codes "D2+000000". Code "D2" enables the display to receive "000000". Since the 3468A is calibrated in the 5½ Digit Mode, make sure that six zeroes (i.e., "000000") are sent instead of just one zero. Also, the "+" between D2 and 000000 needs to be there for the display to accept the numbers correctly.

1. Model 85A.

   OUTPUT 901 ;"D2+000000"

2. Model 41C.

Step#	Action
1.	Press ALPHA button
2.	Enter "D2+000000" from keyboard
3.	Press ALPHA button
4.	Press XEQ button
5.	Press ALPHA button
6.	Enter "OUTA" from keyboard
7.	Press ALPHA button

Steps 1 through 3 enter program codes "D2+000000" into the ALPHA register and steps 4 through 7 output the ALPHA register which sends the codes to the 3468A.

c. The 3468A is now calibrated by sending program code "C" to the instrument. The instrument will then display "CAL", while it is calculating the zero offset calibration constant. When finished, "ZERO DONE" will be displayed for about two seconds. Zero calibration is then completed.

1. Model 85A.

   OUTPUT 901 ;"C"

2. Model 41CV.

Step#	Action
1.	Press ALPHA button
2.	Enter "C" from keyboard
3.	Press ALPHA button
4.	Press XEQ button
5.	Press ALPHA button
6.	Enter "OUTA" from keyboard
7.	Press ALPHA button

Steps 1 through 3 enter program code "C" into the ALPHA register and steps 4 through 7 output the ALPHA register which sends the code to the 3468A.

d. After zero calibration is completed, apply either a full scale (3V) or ⅓ scale (1V) calibration signal to the 3468A's INPUT Terminals. Then set the display to the applied value. Since in this example the applied value is 2.99998V, send program codes "D2+2.99998" to the 3468A.

1. Model 85A.

   OUTPUT 901 ;"D2+2.99998"

2. Model 41CV.

Step#	Action
1.	Press ALPHA button
2.	Enter "D2+2.99998" from keyboard
3.	Press ALPHA button
4.	Press XEQ button
5.	Press ALPHA button
6.	Enter "OUTA" from keyboard
7.	Press ALPHA button

Steps 1 through 3 enter program codes "D2+2.99998" into the ALPHA register and steps 4 through 7 output the ALPHA register which sends the codes to the 3468A.

e. The 3468A is now calibrated by sending program code "C" to the instrument. The instrument will then display "CAL", while it is calculating the 3V gain calibration constant. When finished, "GAIN DONE" will be displayed for about two seconds. The gain calibration is then completed.

1. Model 85A.

```
OUTPUT 901   ;"C"
```

2. Model 41CV.

Step#	Action
1.	Press ALPHA button
2.	Enter "C" from keyboard
3.	Press ALPHA button
4.	Press XEQ button
5.	Press ALPHA button
6.	Enter "OUTA" from keyboard
7.	Press ALPHA button

Steps 1 through 3 enter program code "C" into the ALPHA register and steps 4 through 7 output the ALPHA register which sends the code to the 3468A.

f. The 3V Range in the DC Volts Function is now calibrated. Calibration of the rest of the ranges and functions is done the same way by calibrating with zero and full or ⅓ scale inputs. When calibrating at full or ⅓ scale, make sure the display gets the correct information. For example, to calibrate the gain by applying 1V, send program codes "D2 + 1.00000" to the 3468A. The decimal point included in the number sent to the 3468A (i.e., + 1.00000, + 3.00000. etc.) is not necessary. It is only included to show the value of the calibration voltage to which the 3468A is calibrated.

7-116. Remote Calibration Exceptions

7-117. In remote calibration, as is in local calibration, there are certain exceptions. These are as follows:

a. No calibration is required for the AC Current Function if the AC Volts and DC Current Functions are calibrated. If AC Current calibration is performed, it can only be done at full scale (.3A) on the .3A Range.

b. Full scale or ⅓ scale calibrations can be performed in all functions except the AC Volts Function (and AC Current, see previous paragraph). The AC Volts Function is calibrated only at full scale on only the 3V Range.

PERFORMANCE TEST CARD

24 HOUR LIMITS

Hewlett-Packard Model 3468A
Digital Multimeter

Test Performed By
Date ____ _____

Serial Number ____ _____

Reference Temperature _____

DC Volts Test

Step#	Input to 3468A	Set-Up and Configuration	High Limit	Reading	Low Limit	Test Pass	Test Fail
1	Open	Press TEST/RESET				___	___
2	Short	.3V Range	+.000004V	_____	-.000004V	___	___
3	Short	3V Range	+0.00002V	_____	-0.00002V	___	___
4	Short	30V Range	+00.0003V	_____	-00.0003V	___	___
5	Short	300V Range	+000.002V	_____	-000.002V	___	___
6	+300mV	.3V Range	+.300019V	_____	+.299981V	___	___
7	+300mV	3V Range	+0.30003V	_____	+0.29997V	___	___
8	+1V	3V Range	+1.00006V	_____	+0.99994V	___	___
9	1V	3V Range	1.00006V	_____	0.99994V	___	___
10	3V	3V Range	3.00013V	_____	2.99987V	___	___
11	+3V	3V Range	+3.00013V	_____	+2.99987V	___	___
12	+3V	Autozero Off	+3.00016V	_____	+2.99984V	___	___
13		Autozero On					
14	+3V	4 Digit Disp	+3.0002V	_____	+2.9998V		
15	+3V	3 Digit Disp	+3.001V	_____	+2.999V	___	___
16		5 Digit Disp					
17	+3V	30V Range	+03.0005V	_____	+02.9995V	___	___
18	+10V	30V Range	+10.0008V	_____	+09.9992V	___	___
19	+30V	30V Range	+30.0018V	_____	+29.9982V	___	___
20	+30V	Autozero Off	+30.0029V	_____	+29.9971V	___	___
21		Autozero On					
22	+300V	300V Range	+300.019V	_____	+299.981V	___	___
23	Open	.3V Range					
24	See Below	CMR Test					

CMR Test

1. Connect a 1K ohm resistor between the HI and LO INPUT Terminals of the 3468A.
2. Note the 3468A's reading.
3. Apply 400V dc between the 3468A's HI INPUT and the Power Line Ground.
4. The 3468A should remain within .040mV of the reading in step 2.

PERFORMANCE TEST CARD

90 DAY LIMITS

Hewlett-Packard Model 3468A
Digital Multimeter

Serial Number

Test Performed By.
Date

Reference Temperature

DC Volts Test

Step#	Input 3468A	Set-Up and Configuration	High Limit	Reading	Low Limit	Test Pass	Test Fail
1	Open	Press TEST/RESET					
2	Short	.3V Range	+.000005V		−.000005V		
3	Short	3V Range	+0.00002V		−0.00002V		
4	Short	30V Range	+00.0003V		−00.0003V		
5	Short	300V Range	+000.002V		−000.002V		
6	+300mV	.3V Range	+.300032V		+.299968V		
7	+300mV	3V Range	+0.30004V		+0.29996V		
8	+1V	3V Range	+1.00009V		+0.99991V		
9	−1V	3V Range	1.00009V		−0.99991V		
10	−3V	3V Range	−3.00023V		−2.99977V		
11	+3V	3V Range	+3.00023V		+2.99977V		
12	+3V	Autozero Off	+3.00026V		+2.99974V		
13		Autozero On					
14	+3V	4 Digit Disp	+3.0003V		+2.9997V		
15	+3V	3 Digit Disp	+3.001V		+2.999V		
16		5 Digit Disp					
17	+3V	30V Range	+03.0006V		+02.9994V		
18	+10V	30V Range	+10.0012V		+09.9988V		
19	+30V	30V Range	+30.0030V		+29.9970V		
20	+30V	Autozero Off	+30.0041V		+29.9959V		
21		Autozero On					
22	+300V	300V Range	+300.029V		+299.971V		
23	Open	.3V Range					
24	See Below	CMR Test					

CMR Test

1. Connect a 1K ohm resistor between the HI and LO INPUT Terminals of the 3468A
2. Note the 3468A's reading.
3. Apply 400V dc between the 3468A's HI INPUT and the Power Line Ground.
4. The 3468A should remain within .040mV of the reading in step 2.

PERFORMANCE TEST CARD

1 YEAR LIMITS

Hewlett-Packard Model 3468A
Digital Multimeter

Serial Number____ _____

Test Performed By____
Date_____ _

Reference Temperature. __

DC Volts Test

Step#	Input to 3468A	Set-Up and Configuration	High Limit	Reading	Low Limit	Test Pass	Test Fail
1	Open	Press TEST/RESET					
2	Short	.3V Range	+.000005V	_____	-.000005V	___	___
3	Short	3V Range	+0.00002V	_____	-0.00002V	___	___
4	Short	30V Range	+00.0003V	_____	-00.0003V	___	___
5	Short	300V Range	+000.002V	_____	-000.002V	___	___
6	+300mV	.3V Range	+.300065V	___	+.299935V	___	___
7	+300mV	3V Range	+0.30007V	_____	+0.29993V	___	___
8	+1V	3V Range	+1.00020V	_____	+0.99980V	___	___
9	-1V	3V Range	-1.00020V	_	0.99980V	___	___
10	-3V	3V Range	3.00056V	_____	-2.99944V	___	___
11	+3V	3V	+3.0056V	___	+2.99944V	___	___
12	+3V	Autozero Off	+3.00059V	_____	+2.99941V	___	___
13		Autozero On					
14	+3V	4 Digit Disp	+3.0006V	_	+2.9994V	___	
15	+3V	3 Digit Disp	+3.002V	_____	+2.998V	___	___
16		5 Digit Disp					
17	+3V	30V Range	+03.0009V	_____	+02.9991V	___	___
18	+10V	30V Range	+10.0023V	_____	+09.9977V	___	___
19	+30V	30V Range	+30.0063V	_____	+29.9937V	___	___
20	+30V	Autozero Off	+30.0074V	_____	+29.9926V	___	___
21		Autozero On					
22	+300V	300V Range	+300.062V	_____	+299.938V	___	___
23	Open	.3V Range				___	___
24	See Below	CMR Test				___	___

CMR Test

1. Connect a 1K ohm resistor between the HI and LO INPUT Terminals of the 3468A.
2. Note the 3468A's reading.
3. Apply 400V dc between the 3468A's HI INPUT and the Power Line Ground.
4. The 3468A should remain within .040mV of the reading in step 2.

PERFORMANCE TEST CARD

90 DAY LIMITS

Hewlett-Packard Model 3468A
Digital Multimeter

Test Performed By.
Date

Serial Number

Reference Temperature

DC Current Test

Step#	Input to 3468A	Set-Up and Configuration	High Limit	Reading	Low Limit	Test Pass	Test Fail
1	Open	Press TEST/RESET					
2	Short	DCI Function	+0.00006A		-0.00006A		
3	+1A	3A Range	+1.00146A		+0.99854A		

PERFORMANCE TEST CARD

1 YEAR LIMITS

Hewlett Packard Model 3468A
Digital Multimeter

Test Performed By
Date

Serial Number

Reference Temperature

DC Current Test

Step#	Input to 3468A	Set-Up and Configuration	High Limit	Reading	Low Limit	Test Pass	Test Fail
1	Open	Press TEST/RESET					
2	Short	DCI Function	+0.00006A		-0.00006A		
3	+1A	3A Range	+1.00176A		+0.99824A		

PERFORMANCE TEST CARD

1 YEAR LIMITS

Hewlett-Packard Model 3468A
Digital Multimeter

Test Performed By_____
Date_____

Serial Number_____

Reference Temperature_____

AC Volts Test

Step#	Input to 3468A	Set-Up and Configuration	High Limit	Reading	Low Limit	Test Pass	Test Fail
1	Open	Press TEST/RESET					
2	Open	ACV Function					
3	028V,20KHz	.3V Range	028244V		.027756V		
4	0.28V,20KHz	.3V Range	.280975V		279025V		
5	0.28V,20KHz	3V Range	0.28175V		0.27825V		
6	1.5V,20KHz	3V Range	1.50492V		1.49508V		
7	2.8V,20KHz	3V Range	2.80830V		2.79170V		
8	2.8V,20KHz	30V Range	02.8175V		02.7825V		
9	28V,20KHz	30V Range	28.0830V		27.710 V		
10	28V,20KHz	300V Range	028.194V		027.806V		
11	280V,20KHz	300V Range	281.026V		278.974V		
12	0.28V,50KHz	.3V Range	.281815V		278185V		
13	2.8V,50KHz	3V Range	2.81328V		2.78672V		
14	28V,50KHz	30V Range	28.1328V		27.8672V		
15	280V,50KHz	300V Range	281.720V		278.280V		
16	0 28V,100KHz	.3V Range	285754V		.274246V		
17	0.28V,100KHz	3V Range	0.29119V		0.26881V		
18	2.8V,100KHz	3V Range	2.83765V		2.76235V		
19	15V,100KHz	30V Range	15.2400V		14.7600V		
20	28V,100KHz	30V Range	28.3765V		27.6235V		
21	280V,100KHz	300V Range	284.353V		275.647V		
22	25V,300KHz	30V Range	27.8970V		22.1030V		
23	2.8V,50Hz	3V Range	2.81391V		2.78609V		
24	2.8V,20Hz	3V Range	2.83294V		2.76706V		

PERFORMANCE TEST CARD
1 YEAR LIMITS

Hewlett-Packard Model 3468A
Digital Multimeter

Test Performed By__
Date _____

Serial Number_____

Reference Temperature_____

AC Current Test

Step#	Input to 3468A	Set-Up and Configuration	High Limit	Reading	Low Limit	Test Pass	Test Fail
1	Open	Press TEST/RESET				___	___
2	Open	ACI Function					
3	.01A,5KHz	.3A Range	010263A		.009737A	___	
4	0.1A,5KHz	.3A Range	101163A	_____	.098837A	___	___
5	1A,5KHz	3A Range	1.01863A	_____	0.98137A	___	___

PERFORMANCE TEST CARD

24 HOUR LIMITS

Hewlett Packard Model 3468A
Digital Multimeter

Test Performed By
Date_____

Serial Number_____

Reference Temperature

Ohms Test

Step#	Input to 3468A	Set-Up and Configuration	High Limit	Reading	Low Limit	Test Pass	Test Fail
1	Open	Press TEST/RESET				___	
2	Short	Ohms Function	00.0035	_____	00.0000		___
3	Short	300 Range	000.004	_____	000.000	___	
4	Short	3K Range	0.00002K	_____	0.00000K	___	___
5	Short	30K Range	00.0002K	_____	00.0000K	___	___
6	Short	300K Range	000.002K	_____	000.000K	___	___
7	Short	3M Range	0.00002M	_____	0.00000M	___	___
8	Short	30M Range	00.0002M	_____	00.0000M	___	___
■	300 ohm	300 Range	300.012	_____	299.988	___	___
(9)	100 ohm		100.004	_____	099.996	___	
10	3K ohm	3K Range	3.00014K	_____	2.99986K	___	___
(10)	1K ohm		1.00006K	_____	0.99994K	___	___
11	30K ohm	30K Range	30.0014K	_____	29.9986K	___	___
(11)	10K ohm		10.0006K	_____	09.9994K	___	___
12	300K ohm	300K Range	300.014K	_____	299.986K	___	___
(12)	100K ohm		100.006K	_____	099.994K	___	___
13	3M ohm	3M Range	3.00017M	_____	2.99983M	___	___
(13)	1M ohm		1.00007M	_____	0.99993M	___	___
14	30M ohm	30M Range	30.0110M	_____	29.9890M	___	___
(14)	10M ohm		10.0038M	_____	09.9962M	___	___

PERFORMANCE TEST CARD
90 DAY LIMITS

Hewlett-Packard Model 3468A
Digital Multimeter

Test Performed By_____
Date_____

Serial Number_____

Reference Temperature_____

Ohms Test

Step#	Input to 3468A	Set-Up and Configuration	High Limit	Reading	Low Limit	Test Pass	Test Fail
1	Open	Press TEST/RESET				____	____
2	Short	Ohms Function	00.0041	_____	00.0000	____	____
3	Short	300 Range	000.005	_____	000.000	____	____
4	Short	3K Range	0.00002K	_____	0.00000K	____	____
5	Short	30K Range	00.0002K	_____	00.0000K	____	____
6	Short	300K Range	000.002K	_____	000.000K	____	____
7	Short	3M Range	0.00002M	_____	0.00000M	____	____
8	Short	30M Range	00.0002M	_____	00.0000M	____	____
9	300 ohm	300 Range	300.041	_____	299.959	____	____
(9)	100 ohm		100.017	_____	099.983	____	____
10	3K ohm	3K Range	3.00035K	_____	2.99965K	____	____
(10)	1K ohm		1.00013K	_____	0.99987K	____	____
11	30K ohm	30K Range	30.0035K	_____	29.9965K	____	____
(11)	10K ohm		10.0013K	_____	09.9987K	____	____
12	300K ohm	300K Range	300.035K	_____	299.965K	____	____
(12)	100K ohm		100.013K	_____	099.987K	____	____
13	3M ohm	3M Range	3.00035M	_____	2.99965M	____	____
(13)	1M ohm		1.00013M	_____	0.99987M	____	____
14	30M ohm	30M Range	30.0200M	_____	29.9800M	____	____
(14)	10M ohm		10.0068M	_____	09.9932M	____	____

PERFORMANCE TEST CARD

1 YEAR LIMITS

Hewlett-Packard Model 3468A
Digital Multimeter

Serial Number _____

Test Performed By_____
Date _____

Reference Temperature_____

Ohms Test

Step#	Input to 3468A	Set-Up and Configuration	High Limit	Reading	Low Limit	Test Pass	Test Fail
1	Open	Press TEST/RESET				___	___
2	Short	Ohms Function	00.0041	_____	00.0000	___	___
3	Short	300 Range	000.005	_____	000.000	___	___
4	Short	3K Range	0.00002K	_____	0.00000K	___	___
5	Short	30K Range	00.0002K	_____	00.0000K	___	___
6	Short	300K Range	000.002K	_____	000.000K	___	___
7	Short	3M Range	0.00002M	_____	0.00000M	___	___
8	Short	30M Range	00.0002M	_____	00.0000M	___	___
9	300 ohm	300 Range	300.056	_____	299.944	___	___
(9)	100 ohm		100.022	_____	099.978	___	___
10	3K ohm	3K Range	3.00050K	_____	2.99950K	___	___
(10)	1K ohm		1.00018K	_____	0.99982K	___	___
11	30K ohm	30K Range	30.0050K	_____	29.9950K	___	___
(11)	10K ohm		10.0018K	_____	09.9982K	___	___
12	300K ohm	300K Range	300.050K	_____	299.950K	___	___
(12)	100K ohm		100.018K	_____	099.982K	___	___
13	3M ohm	3M Range	3.00050M	_____	2.99950M	___	___
(13)	1M ohm		1.00018M	_____	0.99982M	___	___
14	30M ohm	30M Range	30.0236M	_____	29.9764M	___	___
(14)	10M ohm		10.0080M	_____	09.9920M	___	___

SECTION V
REPLACEABLE PARTS

5-1. INTRODUCTION

5-2. This section has information for ordering replacement parts. Table 5-3 lists the parts in alphameric order of their reference designators and indicates the description, -hp- Part Number of each part, together with any applicable notes, and provides the following:

a. Total quantity used in the instrument (QTY column). The total quantity of a part is given the first time the part number appears.

b. Description of the part. (See abbreviations listed in Table 5-1.)

c. Typical manufacturer of the part is a five-digit code. (See Table 5-2 for list of manufacturers.)

d. Manufacturers part number.

5-3. Miscellaneous and Chassis Parts are listed at the end of Table 5-3. A disassembly procedure of the instrument is also included with the Miscellaneous and Chassis Parts listing.

5-4. ORDERING INFORMATION

5-5. To obtain replacement parts, address order or inquiry to your local Hewlett-Packard Office. (Office Locations are listed at the back of this manual.) Identify parts by their Hewlett-Packard Part Numbers. Include instrument model and serial number.

5-6. NON-LISTED PARTS

5-7. To obtain a part that is not listed, include:

a. Instrument Model Number
b. Instrument Serial Number
c. Description of the part.
d. Function and location of the part.

5-8. PARTS CHANGES

5-9. Components which have been changed are so marked by one of three symbols; i.e., Δ, Δ with a letter subscript, e.g., Δ_a, or Δ with a number subscript, e.g., Δ_{10}. A Δ with no subscript indicates the component listed is the preferred replacement for an earlier component. A Δ with a letter subscript indicates a change which is explained in ■ note at the bottom of the page. A Δ with a number subscript indicates the related change is discussed in backdating (Section VI). The number of the subscript indicates the number of the change in backdating which should be referred to.

5-10. PROPRIETY PARTS

5-11. Items marked with a dagger (†) in the reference designator column are available only for repair and service of Hewlett-Packard Instruments.

Table 5-1. Standard Abbreviations

ABBREVIATIONS

Ag	silver
Al	aluminum
■	ampere(s)
Au	gold
C	capacitor
cer	ceramic
coef	coefficient
com	common
comp	composition
conn	connection
dep	deposited
DPDT	double-pole double-throw
DPST	double-pole single-throw
elect	electrolytic
■	encapsulated
F	farad(s)
FET	field effect transistor
fxd	fixed
GaAs	gallium arsenide
GHz	gigahertz = 10^{+9} hertz
gd	guard(ed)
Ge	germanium
gnd	ground(ed)
H	henry(ies)
Hg	mercury
■	hertz (cycle(s) per second)
ID	inside diameter
impg	impregnated
incd	incandescent
■	insulation(ed)
■	kilohm(s) = 10^{+3} ohms
kHz	kilohertz = 10^{+3} hertz
L	inductor
lin	linear taper
log	logarithmic taper
mA	milliampere(s) = 10^{-3} amperes
MHZ	megahertz = 10^{+6} hertz
■	megohm(s) = 10^{+6} ohms
met film	metal film
mfr	manufacturer
■	millisecond
mtg	mounting
mV	millivolt(s) = 10^{-3} volts
μF	microfarad(s)
■	microsecond(s)
μV	microvolt(s) = 10^{-6} volts
my	Mylar ®
nA	nanoampere(s) = 10^{-9} amperes
NC	normally closed
Ne	neon
NO	normally open
NPO	negative positive zero (zero temperature coefficient)
■	nanosecond(s) = 10^{-9} seconds
■	not seperately replaceable
Ω	ohm(s)
obd	order by description
OD	outside diameter
p	peak
pA	picoampere(s)
pc	printed circuit
pF	picofarad(s) 10^{-12} farads
piv	peak inverse voltage
p/o	part of
pos	position(s)
poly	polystyrene
■	potentiometer
p-p	peak-to-peak
ppm	■ per million
prec	■ (temperature coefficient, long term stability and/or tolerence)
R	■
Rh	rhodium
rms	root-mean-square
rot	rotary
Se	selenium
sect	section(s)
■	silicon
sl	slide
SPDT	single-pole double-throw
SPST	single-pole single-throw
Ta	tantalum
TC	temperature coefficient
TiO_2	titanium dioxide
tog	toggle
tol	tolerance
trim	trimmer
TSTR	transistor
V	volt(s)
vacw	alternating current working voltage
■	variable
vdcw	direct current working voltage
■	watt(s)
w/	with
wiv	working inverse voltage
w/o	without
ww	wirewound
+	optimum value selected ■ factory, average value shown (part may be omitted)
--	no standard type number assigned selected or special type

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■

A	assembly
B	motor
BT	battery
C	capacitor
CR	diode ■ thyristor
DL	delay line
DS	lamp
E	■ electronic part
F	fuse
FL	■
HR	heater
IC	integrated circuit
J	jack
K	relay
L	■
M	■
■	■ part
P	plug
Q	transistor
■	transistor-diode
R(p)	resistor(pack)
RT	thermistor
S	switch
T	transformer
TB	terminal board
TC	thermocouple
TP	test point
TS	terminal strip
U	microcircuit
V	vacuum tube, neon bulb, photocell, etc.
W	■ble
X	socket
XDS	lampholder
■	fuseholder
Y	crystal
Z	network

Table 5-2. Code List of Manufacturers

Mfr. No.	Manufacturer Name	Address
0049D	United Chemicon Inc	
01121	Allen-Bradley Co	Milwaukee WI 53204
01295	Texas Instr Inc Semicond Cmpnt Div	Dallas TX 75222
0192B	RCA Corp Solid State Div	Somerville NJ 08876
03888	KDI Pyrofilm Corp	Whippany NJ 07981
04713	Motorola Semiconductor Products	Phoenix AZ 85062
06665	Precision Monolithics Inc	Santa Clara CA 95050
07263	Fairchild Semiconductor Div	Mountain View CA 94042
07716	TRW Inc Burlington Div	Burlington IA 52601
11236	Cts of Berne Inc	Berne IN 46711
12969	Unitrode Corp	Watertown MA 02172
14936	General Instr Corp Semidon Prod Gp	Hicksville NY 11802
24355	Analog Devices Inc	Norwood MA 02062
24546	Corning Glass Works (Bradford)	Bradford PA 16701
27014	National Semiconductor Corp	Santa Clara CA 95051
28480	Hewlett-Packard Co Corporate Hq	Palo Alto CA 94304
32293	Intersil Inc	Cupertino CA 94014
56289	Sprague Electric Co	North Adams MA 01247
71400	Bussman Mfg Div of McGraw-Edison Co	St. Louis MO 63107
75042	TRW Inc Philadelphia Div	Philadelphia PA 19108
75915	Littlefuse Inc	Des Plaines IL 60016

5-12. 3468A DISASSEMBLY PROCEDURE

5-13. The following is the complete disassembly procedure for the 3468A. The procedure also includes the disassembly of the Battery Charger assembly (Option 001).

a. Make sure the 3468A is turned off and ac power is disconnected from the instrument.

b. Turn the 3468A upside down and then refer to Figure 5-2. Loosen screws MP3, but do not attempt to remove the srews from the 3468A's bottom assembly (MP6). The screws are held in the assembly by "O" rings.

c. Turn the 3468A right side up facing you. Lift the 3468A's top assembly (MP7) up about an inch or so, away from the bottom assembly. Then place the top assembly next to the bottom assembly, as shown in Figure 5-3.

d. If the battery option is installed, disconnect cable W901 from the A1 assembly (mother board) mounted in the bottom assembly. If the battery and/or the battery charger printed circuit board is to be removed, do the following:

1. Refer to Figure 5-8. Disconnect the wires from the battery, then loosen and remove screws MP18.

2. The battery charger printed circuit board can now be removed. Once the board is removed, remove the battery cover (MP20) and then the battery.

3. The battery charger is now disassembled.

d. Remove handle MP5 from the bottom assembly.

e. If the display (MP16) is to remain in the 3468A, continue with step f. If the display is to be removed, do the following:

1. Refer to Figure 5-7. Unplug cable W501 from the display assembly.

2. Loosen and remove screws MP15 from the front panel assembly (MP2).

3. Remove the display assembly.

f. Refer to Figure 5-4. Loosen and remove screw MP9 from the inner shield (MP10). Then remove the inner shield.

g. Refer to Figure 5-5. Loosen and remove screws MP11 from the A1 assembly (main printed circuit board).

h. Remove the A1 assembly by lifting it up and out of the 3468A's bottom assembly (MP6). Set the bottom assembly aside.

i. Refer to Figure 5-7. Unplug cable W501 from the display assembly (MP16). Then unplug the wires going to the front panel terminals.

j. Refer to Figure 5-7. Loosen and remove screws MP17 from the A1 assembly. Remove the front panel assembly (MP2) from the A1 assembly. The instrument is now disassembled.

Table 5-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A1	03468-66501	0	1	PC ASSEMBLY-MOTHER BOARD	28480	03468-66501
A1BT551	1420-0278	7	1	BATTERY 3V 95A-HR LI/S-DIOX W-FLEX	28480	1420-0278
A1C101	0160-4438	6	3	CAPACITOR-FXD 470PF +-2.5% 160VDC POLYP	28480	0160-4438
A1C102	0160-4438	6		CAPACITOR-FXD 470PF +-2.5% 160VDC POLYP	28480	0160-4438
A1C103	0160-4438	6		CAPACITOR-FXD 470PF +-2.5% 160VDC POLYP	28480	0160-4438
A1C104	0150-0012	3	1	CAPACITOR-FXD .01UF +-20% 1KVDC CER	56289	C023A102J103M5S8
A1C201	0160-4800	6	3	CAPACITOR-FXD 120PF +-5% 100VDC CER	28480	0160-4800
A1C202	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A1C203	0160-4832	4	2	CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A1C301	0160-5386	5	1	CAPACITOR-FXD .15UF 630VDC	28480	0160-5386
A1C302	0160-5384	3	1	CAPACITOR-FXD 2.7PF 400VDC	28480	0160-5384
A1C304	0180-0228	6	2	CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2
A1C305	0160-4803	9	1	CAPACITOR-FXD 68PF +-5% 100VDC CER 0+-30	28480	0160-4803
A1C306	0180-0228	6		CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2
A1C307	0160-5385	4	1	CAPACITOR-FXD 1.8UF 100VDC	28480	0160-5385
A1C308	0180-2205	3	1	CAPACITOR-FXD .33UF+-10% 35VDC TA	56289	150D334X9035A2
A1C309	0180-0373	2	1	CAPACITOR-FXD 68UF+-10% 35VDC TA	56289	150D684X9035A2
A1C310	0180-0291	3	[illegible]	CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A1C311	0160-4571	[illegible]	13	CAPACITOR-FXD .1UF +80-20% 50VDC CER	28480	0160-4571
A1C312	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	28480	0160-4571
A1C313	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A1C401	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	28480	0160-4571
A1C402	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	28480	0160-4571
A1C404	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	28480	0160-4571
A1C405	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	28480	0160-4571
A1C411	0160-4814	2	[illegible]	CAPACITOR-FXD 150PF +-5% 100VDC CER	28480	0160-4814
A1C412	0160-4830	2	1	CAPACITOR-FXD 2200PF +-10% 100VDC CER	28480	0160-4830
A1C410	0160-5392	3	1	CAPACITOR-FXD 1500PF +-10% 100VDC CER	28480	0160-5392
A1C430	0160-4823	4	[illegible]	CAPACITOR-FXD [illegible] +-5% 100VDC [illegible]	28480	0160-4823
A1C431	0160-4832	4	2	CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A1C501	0160-3335	[illegible]		CAPACITOR-FXD 470PF +-10% 100VDC CER	28480	0160-3335
A1C503	0160-4532	1	2	CAPACITOR-FXD 1000PF +-20% 50VDC [illegible]	28480	0160-4532
A1C504	0160-4800	6		CAPACITOR-FXD 120PF +-5% 100VDC CER	28480	0160-4800
A1C505	0160-4807	5	2	CAPACITOR-FXD 33PF +-5% 100VDC CER 0+-30	28480	0160-4807
A1C506	0160-4807	5		CAPACITOR-FXD 33PF +-5% 100VDC [illegible] 0+-30	28480	0160-4807
A1C507	0160-4571	[illegible]		CAPACITOR-FXD .1UF +80-20% 50VDC CER	28480	0160-4571
A1C508	0160-4810	9	2	CAPACITOR-FXD 330PF +-5% 100VDC [illegible]	28480	0160-4810
A1C509	0160-4810	[illegible]		CAPACITOR-FXD 330PF +-5% 100VDC CER	28480	0160-4810
A1C550	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	28480	0160-4571
A1C551	0180-0291	[illegible]		CAPACITOR-FXD 1UF+-10% 35VDC [illegible]	56289	150D105X9035A2
A1C552	0160-4830	2		CAPACITOR-FXD 2200PF +-10% 100VDC CER	28480	0160-4830
A1C702	0180-2986	7	4	CAPACITOR-FXD 330UF+-20% 50VDC AL	28480	0180-2986
A1C703	0180-2986	7		CAPACITOR-FXD 330UF+-20% 50VDC AL	28480	0180-2986
A1C705	0180-0117	2	2	CAPACITOR-FXD 2.7UF+-10% 35VDC TA	56289	150D275X9035B2
A1C706	0180-0117	2		CAPACITOR-FXD 2.7UF+-10% 35VDC TA	56289	150D275X9035B2
A1C707	0160-4571	[illegible]		CAPACITOR-FXD .1UF +80-20 50VDC CER	28480	0160-4571
A1C731	0180-0693	9	[illegible]	CAPACITOR-FXD 1000UF+50-10% 25VDC AL	00499	25VBSL1000
A1C740	0180-2986	7		CAPACITOR-FXD 330UF+-20% 50VDC AL	28480	0180-2986
A1C741	0180-2986	7		CAPACITOR-FXD 330UF+-20% 50VDC AL	28480	0180-2986
A1C707	0160-4571	8	1	CAPACITOR-FXD .1UF +80-20% 50VDC CER	28480	0160-4571
A1C742	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A1CR201	1901-0849	8	1	DIODE-PWR RECT 1N4007 1KV 1A DO-41	14936	1N4007
A1CR202	1902-0184	6	1	DIODE-ZNR 16.2V 5% DO-35 PD=.4W	28480	1902-0184
A1CR401	1826-0918	7	1	IC-V REGLTR-FXD-POS 5.677 .25V-TO 92PKG	28480	1826-0918
A1CR501	1901-0040	1	[illegible]	DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A1CR550	1901-0518	8	1	DIODE-SM SIG SCHOTTKY	28480	1901-0518
A1CR551	1901-0050	3	10	DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A1CR552	1902-0970	8	2	DIODE-ZNR 33V 5% DO-35 PD=.4W TC=+.097%	28480	1902-0970
A1CR553	1902-0970	8		DIODE-ZNR 33V 5% DO-35 PD=.4W TC=+.097%	28480	1902-0970
A1CR554	1901-0050	3		DIODE-SWITCHING [illegible] 200MA 2NS DO-35	28480	1901-0050
A1CR555	1901-0050	3		DIODE-SWITCHING [illegible] 200MA 2NS DO-35	28480	1901-0050
A1CR556	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A1CR701	1901-0743	1	24	DIODE-PWR RECT 1N4004 400V 1A DO-41	01295	1N4004
A1CR702	1901-0743	1		DIODE-PWR RECT 1N4004 400V 1A DO-41	01295	1N4004
A1CR703	1901-0743	1		DIODE-PWR RECT 1N4004 400V 1A DO-41	01295	1N4004
A1CR704	1901-0743	1		DIODE-PWR RECT 1N4004 400V 1A DO-41	01295	1N4004
A1CR705	1901-0743	1		DIODE-PWR RECT 1N4004 400V 1A DO-41	01295	1N4004
A1CR706	1901-0743	1		DIODE-PWR RECT 1N4004 400V 1A DO-41	01295	1N4004
A1CR707	1901-0743	1		DIODE-PWR RECT 1N4004 400V 1A DO-41	01295	1N4004
A1CR711	1902-0632	9	2	DIODE-ZNR 1N5354B 17V 5% PD=5W TC=+75%	04713	1N5354B
A1CR712	1902-0936	6	1	DIODE-ZNR 6V PD=5W IR=300UA	12969	TVS505
A1CR713	1902-0632	9		DIODE-ZNR 1N5354B 17V 5% PD=5W TC=+75%	04713	1N5354B
A1CR749	1902-0654	5	2	DIODE-ZNR 33.2V 5% DO-15 PD=1W TC=+.075%	28480	1902-0654
A1CR750	1902-0654	5		DIODE-ZNR 33.2V 5% DO-15 PD=1W TC=+.075%	28480	1902-0654
A1CR751	1901-0743	1		DIODE-PWR RECT 1N4004 400V [illegible] DO-41	01295	1N4004
A1CR752	1901-0743	1		DIODE-PWR RECT 1N4004 400V [illegible] DO-41	01295	1N4004

See introduction to this section for ordering information
*Indicates factory selected value

Table 5-3. Replaceable Parts (Cont'd)

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A1E101	1970-0090	6	1	TUBE-ELECTRON 630V	28480	1970-0090
A1F101	2110-0003	1	1	FUSE 3A 250V NTD 1.25X.25 UL	75915	312003
A1F730	2110-0234	9	1	FUSE .1A 250V TD 1.25X.25 UL	71400	MDL 1/10,
A1FX730	2110-0643	4	3	FUSEHOLDER-CAPTIVE CLIP	28480	2110-0643
A1H701	1205-0309	9	1	HEAT SINK SGL TO-220-CS	28480	1205-0309
A1J701	1200-0607	0	1	SOCKET-IC 16-CONT DIP DIP-SLDR	28480	1200-0607
A1K101	0490-1310	6	1	RELAY-REED CR-2583	28480	0490-1310
A1K102	0490-1309	3	3	RELAY-REED CR-2584	28480	0490-1309
A1K103	0490-1309	3		RELAY-REED CR-2584	28480	0490-1309
A1K104	0490-1309	3		RELAY-REED CR-2584	28480	0490-1309
A1L201	9100-1651	2	1	INDUCTOR RF-CH-MLD 250UH 5% [illegible]	28480	9100-1651
A1L501	9100-1631	8	1	INDUCTOR RF-CH-MLD 56UH 5% .166DX.385LG	28480	9100-1631
A1P702	1251-4743	0		CONNECTOR-AC PWR HP-9 MALE REC-FLG THRMP	28480	1251-4743
A1P702	1251-4743	0	2	CONNECTOR-AC [redacted] HP-9 MALE REC-FLG THRMP	28480	1251-4743
A1Q201	1853-0510	7	4	TRANSISTOR-2N6520 (SEL)	28480	1853-0510
A1Q202	1853-0510	7		TRANSISTOR-2N6520 (SEL)	28480	1853-0510
A1Q203	1853-0510	7		TRANSISTOR-2N6520 (SEL)	28480	1853-0510
A1Q204	1853-0510	7		TRANSISTOR-2N6520 (SEL)	28480	1853-0510
A1Q205	1855-0298	2	1	TRANSISTOR J-FET N-CHAN D MODE TO-92	28480	1855-0298
A1R101	0686-5135	6	[illegible]	RESISTOR 51K 5% .5W CC TC=0+765	01121	CB5135
A1R102	0686-5135	6		RESISTOR 51K 5% .5W CC TC=0+765	01121	CB5135
A1R103	0686-5135	[illegible]		RESISTOR 51K [redacted] .5W [redacted] TC=0+765	01121	CB5135
A1R104	0686-5135	[illegible]		RESISTOR 51K 5% [redacted] CC TC=0+765	01121	CB5135
A1R105	0686-5135	6		RESISTOR 51K 5% .5W CC TC=0+765	01121	CB5135
A1R106	0686-5135	6		RESISTOR 51K 5% .5W CC TC=0+765	01121	CB5135
A1R107	0811-3435	2	1	RESISTOR .1 .1% 3W PW TC=0+-90	28480	0811-3435
A1R108	0686-5135	6		RESISTOR 51K 5% .5W CC TC=0+765	01121	CB5135
A1R109	0686-5135	6		RESISTOR 51K 5% .5W CC TC=0+765	01121	CB5135
A1R110	0698-8777	3	2	RESISTOR 1K 5% .25W CC TC=-400/+900	28480	0698-8777
A1R201	0698-8093	[illegible]	1	RESISTOR 40K .1% .1W [illegible] TC=0+-5	07716	MARS-1/10 [illegible]
A1R202	0683-2445	9	2	[redacted] 240K 5% .25W FC TC=-800/+900	01121	CB2445
A1R203	0683-2445	9		RESISTOR 240K 5% .25W FC TC=-800/+900	01121	CB2445
A1R204	0683-4715	0	1	[redacted] 470 5% .25W FC TC=-400/+600	01121	CB4715
A1R205	0683-4325	8	1	RESISTOR 4.3K [redacted] .25W FC TC=-400/+700	01121	CB4325
A1R302	0698-6670	1	[illegible]	RESISTOR 1K .5% .125W F TC=0+-25	28480	0698-6670
A1R303	0698-6520	[illegible]	1	RESISTOR 24K .25% .125W [illegible] TC=0+-25	28480	0698-6520
A1R304	0683-2435	7	1	RESISTOR 24K 5% .25W FC TC=-400/+800	01121	CB2435
A1R305	0757-0457	6	1	RESISTOR 47.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4752-F
A1R306	0683-1005	5	3	RESISTOR [redacted] .25W FC TC=-400/+500	01121	CB1005
A1R307	0683-1005	5		RESISTOR 10 5% .25W FC TC=-400/+500	01121	CB1005
A1R401	0683-1655	1	1	RESISTOR 1.6M 5% .25W FC TC=-900/+1100	01121	CB1655
A1R402	0698-8353	1	1	RESISTOR [redacted] 1% .125W F TC=0+-100	28480	0698-8353
A1R403	0698-4539	7	1	RESISTOR 402K 1% .125W F TC=0+-100	28480	0698-4539
A1R404	0757-0472	5	1	RESISTOR 200K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2003-F
A1R405	0757-0465	6	5	RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A1R406	0698-3228	9	2	RESISTOR 49.9K 1% .125W F TC=0+-100	28480	0698-3228
A1R407	0683-8255	1	2	RESISTOR 8.2M 5% .25W FC TC=-900/+1100	01121	CB8255
A1R408	0683-1005	5		RESISTOR 10 5% .25W FC TC=-400/+500	01121	CB1005
A1R409	0757-0415	6	1	RESISTOR 475 1% .125W F TC=0+-100	24546	C4-1/8-T0-475R-F
A1R438	0757-0273	4	1	RESISTOR 3.01K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3011-F
A1R439	0698-8827	4	2	RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827
A1R501	1810-0162	5	2	NETWORK-RES 14-DIP4.7K OHM X 13	11236	760-1-R4.7K
A1R502	0683-8255	1		RESISTOR 8.2M 5% .25W FC TC=-900/+1100	01121	CB8255
A1R503	0683-1535	6	4	RESISTOR 15K 5% .25W FC TC=-400/+800	01121	CB1535
A1R504	0683-1535	6		RESISTOR 15K 5% .25W FC TC= 400/+800	01121	CB1535
A1R505	0698-3446	3	2	RESISTOR 383 1% .125W F TC=0+-100	24546	C4-1/8-T0-383R-F
A1R506	0698-3446	3		RESISTOR 383 1% .125W F TC=0+-100	24546	C4-1/8-T0-383R-F
A1R507	0683-1535	6		RESISTOR 15K 5% .25W FC TC=-400/+800	01121	CB1535
A1R551	0698-4482	9	1	RESISTOR 17.4K 1% .125W F TC=0+-100	03888	PME55 1/8-T0-1742-F
A1R552	0698-3359	7	2	RESISTOR 12.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1272-F
A1R553	0698-8827	4		RESISTOR 1M 1% .125W F TC=0+-100	28480	0698-8827
A1R561	1810-0560	7	1	RESISTIVE NETWORK-8 X 5.6K OHM	28480	1810-0560
A1R562	0698-3359	7		RESISTOR 12.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1272-F
A1R564	0698-8777	3		RESISTOR 1K 5% .25W CC TC=-400/+900	28480	0698-8777
A1R565	0698-8777	3		RESISTOR 1K 5% .25W CC TC=-400/+900	28480	0698-8777
A1R567	0698-8777	3		RESISTOR [redacted] 5% .25W CC TC=-400/+900	28480	0698-8777
A1R568	1810-0269	3	2	NETWORK-RES 9-SIP10.0K OHM X 8	28480	1810-0269

See introduction to this section for ordering information
*Indicates factory selected value

Table 5-3. Replaceable Parts (Cont'd)

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A1R708	0698-8777	3		RESISTOR 1K 5% .25W CC TC=-400/+900	28480	0698-8777
A1R740	0812-0040	1	1	RESISTOR .27 5% .5W PW TC=0+-300	75042	BW20-1/2-27/100-J
A1R741	0683-1535	6		RESISTOR 15K 5% .25W FC TC=-400/+800	01121	CB1535
A1RT563	0837-0220	1	2	THERMISTOR-ROD TP 10K	28480	0837-0220
A1RT705	0837-0225	6	1	THERMISTOR-PTC 2.5 .30	28480	0837-0225
A1RT706	0837-0223	4	2	THERMISTOR-PTC 10.30	28480	0837-0223
A1RT707	0837-0223	4		THERMISTOR-PTC 10.30	28480	0837-0223
A1S501	3101-2243	6	1	SWITCH-RKR DIP-RKR-ASSY 8 1A 05A 30VDC	28480	3101-2243
A1S730	3101-1723	5	1	SWITCH-PB 4PDT .45A 115VAC	28480	3101-1723
A1T501	9100-4199	9	1	TRANSFORMER-INTERFACE PTL R	28480	9100-4199*
A1T502	9140-0600	3	1	TRANSFORMER-P/L DRIVER	28480	9140-0600
A1T730	9100-4202	5	1	TRANSFORMER-POWER	28480	9100-4202
A1U101	1826-0822	7	1	IC OP AMP PRCN TO-99 PKG	24355	AD542KH
A1U201	1826-0493	8	2	IC OP AMP LOW-BIAS-H-IMPD 8 DIP-P PKG	04713	MLM308AP1
A1U202	1826-0493	8		IC OP [redacted] LOW-BIAS-H-IMPD 8-DIP-P PKG	04713	MLM308AP1
A1U203	1826-0072	9	1	IC OP AMP LOW-BIAS-H-IMPD TO-99 PKG	07263	UA208H
A1U301	1826-0887	4	1	IC-LF412CN (SEL)	28480	1826-0887
A1U102	1QF7-0067	6	1		28480	1QF7-0067
A1U302	1826-0357	3	1	IC OP AMP WB TO-99 PKG	27014	LF357H
A1U303	1826-0893	2	1	IC-CONV AD536AJH	28480	1826-0893
A1U401	1826-0059	2	1	IC OP AMP GP TO-99 PKG	01295	LM201AL
A1U402	1826-0635	0	2	IC [redacted] AMP LOW-OFS 8-DIP-P PKG	06665	OP-07CP
A1U403	1QF6-0066	3	1	PCB HYBRID A/D	28480	1QF6-0066
A1U404	1826-0271	0	1	IC OP AMP GP 8-DIP-P PKG	01295	SN72741P
A1U405	1826-0635	0		IC OP AMP LOW-OFS 8-DIP-P PKG	06665	OP-07CP
A1U501	1820-2718	2	1	IC-INS 8039LN-11	28480	1820-2718
A1U502	1818-1753	8	1	IC-MK36000N-5	28480	1818-1753
A1U503	1LB3-0003	9	1	IC-HPIL 28-PIN	28480	1LB3-0003
A1U504	1820-2702	4	1	IC NMOS 16384-BIT PROM	28480	1820-2702
A1U505	1820-1578	0	2	IC SHF-RGTR [redacted] D-TYPE PRL IN PRL OUT	01928	CD4076BE
A1U507	1820-1578	[redacted]		IC SHF-RGTR CMOS D-TYPE PRL-IN PRL-OUT	01928	CD4076BE
A1U508	1820-2102	8	1	IC LCH TTL LS D-TYPE OCTL	01295	SN74LS373N
A1U509	1818-1754	9	1	IC RAM MOS 5101L	28480	1818-1754
A1U550	1826-0412	1	1	IC COMPARATOR PRCN DUAL 8-DIP-P PKG	27014	LM393N
A1U701	1826-0551	9	1	IC 340A V RGLTR TO-220	01295	TL2805ACK(
A1U702	1826-0214	1	1	IC V RGLTR TO-220	04713	MC7915CT
A1U703	1826-0607	6	1	IC-LM340AT-15	28480	1826-0607
A1W501	8120-3479	7	1		28480	8120-3479
A1W502	5061-1165		1	CONNECTOR-HPIL	28480	5061-1165
				A1 MISCELLANEOUS PARTS		
A1Y501	0410-1332	4	1	CRYSTAL-6.003 MHZ	28480	0410-1332
	1460-1485	4	1	STAMPING-SPRING FUSE	28480	1460-1485
A3	03468-80001	[redacted]	1	3468A OPT. 001 (BATTERY OPT.)	28480	03468-80001
A3	03468-66503	2	1	PC ASSEMBLY-BATTERY CHARGER	28480	03468-66503
A3C901	0180-3148	5	1	CAPACITOR-FXD 2200UF 25VDC	28480	0180-3148
A3C902	0160-0127	2	1	CAPACITOR-FXD 1UF +-20% 25VDC CER	28480	0160-0127
A3C903	0160-4571	8		CAPACITOR-FXD .1UF +80-20 50VDC CER	28480	0160-4571
A3C904	0160-4571	8		CAPACITOR-FXD .1UF +80-20 50VDC CER	28480	0160-4571
A3C906	0180-0486	[redacted]	1	CAPACITOR-FXD 10UF+-10 20VDC TA	28480	0180-0486
A3C907	0160-4571	8		CAPACITOR-FXD .1UF +80-20 50VDC CER	28480	0160-4571
A3C908	0160-4571	8		CAPACITOR-FXD 1UF +80-20% 50VDC CER	28480	0160-4571
A3C909	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	28480	0160-4571
A3C910	0180-1745	4	2	CAPACITOR-FXD 1.5UF+-10% 20VDC TA	56289	150D155X9020A2
A3C911	0160-4813	1	1	CAPACITOR-FXD 180PF +-5% 100VDC CER	28480	0160-4813
A3C912	0180-1745	4		CAPACITOR-FXD 1.5UF+-10% 20VDC TA	56289	150D155X9020A2
A3CR901	1901-0743	1		DIODE-PWR RECT 1N4004 400V 1A DO-41	01295	1N4004
A3CR902	1901-0743	1		DIODE-PWR RECT 1N4004 400V 1A DO-41	01295	1N4004
A3CR903	1901-0743	1		DIODE-PWR RECT 1N4004 400V 1A DO-41	01295	1N4004
A3CR904	1901-0743	1		DIODE [redacted] RECT 1N4004 400V 1A DO-41	01295	1N4004
A3CR905	1901-0743	1		DIODE-PWR RECT 1N4004 400V 1A DO-41	01295	1N4004
A3CR906	1901-0743	1		DIODE-PWR RECT 1N4004 400V 1A DO-41	01295	1N4004
A3CR907	1901-0743	1		DIODE-PWR RECT 1N4004 400V 1A DO-41	01295	1N4004
A3CR908	1901-0050	3		DIODE-SWITCHING 80V [redacted] 2NS DO-35	28480	1901-0050
A3CR909	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A3CR910	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A3CR911	1901-0050	3		DIODE-SWITCHING [redacted] 2NS DO-35	28480	1901-0050
A3CR912	1901-0743	1		DIODE-PWR RECT 1N4004 [redacted] 1A DO-41	01295	1N4004
A3CR913	1901-0743	1		DIODE-PWR RECT 1N4004 400V 1A DO-41	01295	1N4004
A3CR914	1901-0743	1		DIODE-PWR RECT 1N4004 400V 1A DO-41	01295	1N4004
A3CR915	1901-0743	1		DIODE-PWR RECT 1N4004 400V 1A DO-41	01295	1N4004
A3CR916	1901-0743	1		DIODE-PWR RECT 1N4004 400V 1A DO-41	01295	1N4004
A3CR917	1901-0743	1		DIODE-PWR RECT 1N4004 400V 1A DO-41	01295	1N4004
A3CR918	1901-0743	1		DIODE-PWR RECT 1N4004 400V 1A DO-41	01295	1N4004
A3CR919	1901-0743	1		DIODE-PWR RECT 1N4004 400V 1A DO-41	01295	1N4004
A3CR920	1901-0050	3		DIODE-SWITCHING [redacted] 200MA 2NS DO-35	28480	1901-0050

See introduction to this section for ordering information
*Indicates factory selected value

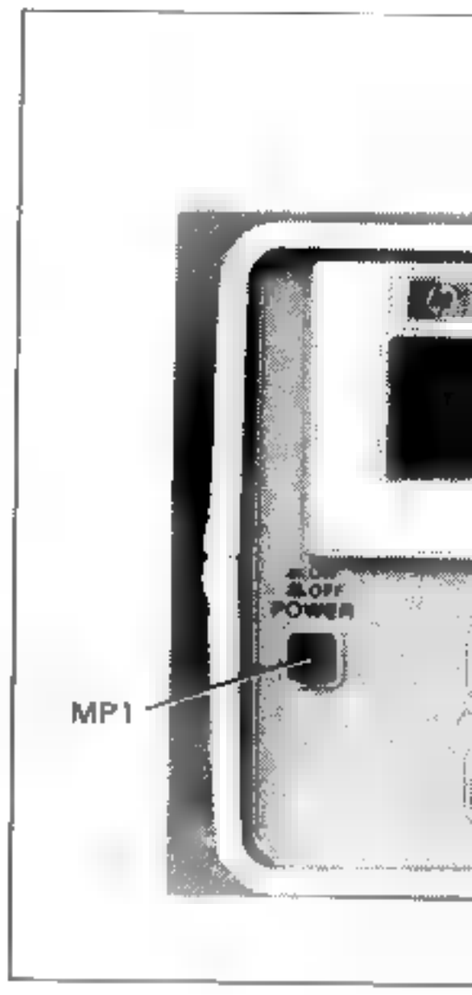
Table 5-3. Replaceable Parts (Cont'd)

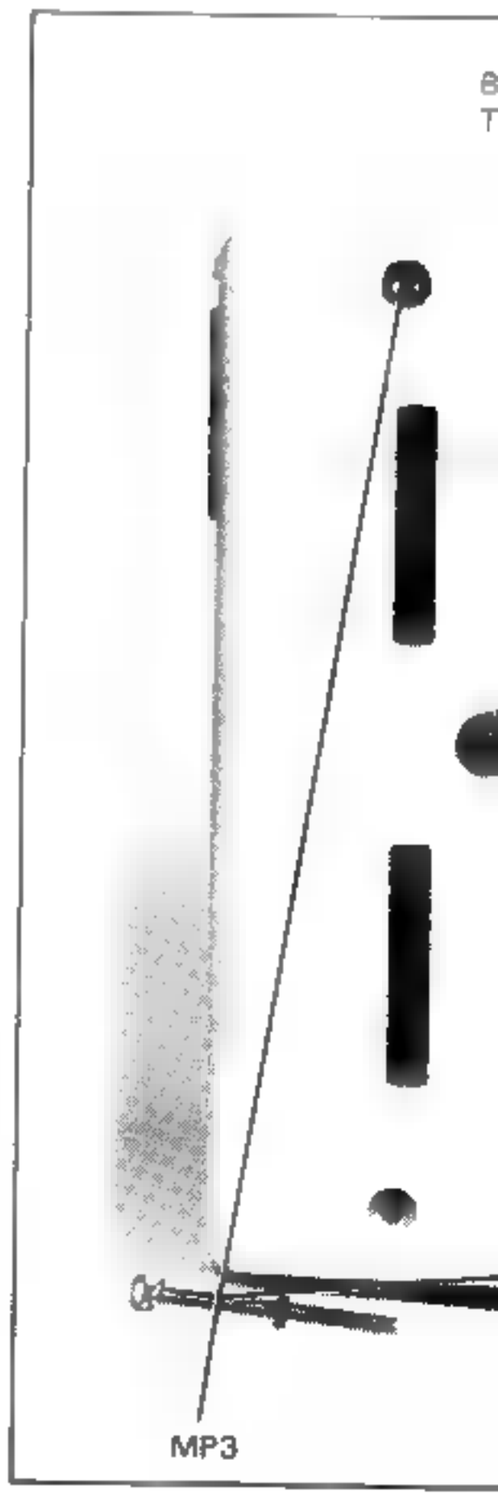
Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A3CR921	1901-0050	3		DIODE-SWITCHING [redacted] 200MA 2NS DO-35	28480	1901-0050
A3F901	2110-0002	9	1	FUSE 7A 250V NB	75915	312002
A3FX901	2110-0643	4		FUSEHOLDER-CAPTIVE CLIP	28480	2110-0643
A3FX901	2110-0643	4		FUSEHOLDER-CAPTIVE CLIP	28480	2110-0643
A3H901	1205-0448	7	1	HEATSINK-TO3 MOUNT	28480	1205-0448
A3H904	1205-0452	3	1	HEATSINK-TO66 BOARD MOUNT	28480	1205-0452
A3Q901	1853-0305	8	1	TRANSISTOR PNP 2N5875 SI TO 3 PD=150W	04713	2N5875
A3Q902	1854-0472	2	2	TRANSISTOR NPN SI DARL PD=500MW	04713	MPS-A14
A3Q903	1854-0087	5	1	TRANSISTOR [redacted] SI PD=360MW FT=75MHZ	28480	1854-0087
A3Q904	1854-0756	5	[redacted]	TRANSISTOR NPN 2N6315 SI TO-66 PD=90W	04713	2N6315
A3Q905	1854-0472	2		TRANSISTOR [redacted] SI DARL PD=500MW	04713	MPS-A14
A3R901	0757-0449	6	1	RESISTOR 20K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2002-F
A3R902	0757-0442	9	1	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A3R903	0699-0032	9	1	RESISTOR 71.05K .25% .125W F TC=0+-50	28480	0699-0032
A3R904	0698-6270	7	1	RESISTOR 125K .25% .125W F TC=0+-50	28480	0698-6270
A3R905	0683-3335	8	2	RESISTOR 33K 5% .25W FC TC=-400/+800	01121	CB3335
A3R906	0683-2715	6	2	RESISTOR 270 5% .25W FC TC=-400/+600	01121	CB2715
A3R907	0683-6835	9	2	RESISTOR 68K 5% .25W FC TC=-400/+800	01121	CB6835
A3R908	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A3R909	0698-3558	8	1	RESISTOR 4.02K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4021-F
A3R910	0698-3440	7	[redacted]	RESISTOR 196 1% .125W F TC=0+-100	24546	C4-1/8-T0-196R-F
A3R911	0757-0467	8	1	RESISTOR 121K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1213-F
A3R912	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A3R913	0683-6835	9		RESISTOR 68K 5% .25W FC TC=-400/+800	01121	CB6835
A3R914	0683-3055	9	1	RESISTOR 3M 5% .25W FC TC=-900/+1100	01121	CB3055
A3R915	0698-0077	[redacted]	1	RESISTOR 93.1K 1% .125W F TC=0+-100	03888	PME55-1/8-T0-9312-F
A3R916	0698-3452	1	1	RESISTOR 147K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1473-F
A3R918	0683-3335	8		RESISTOR 33K 5% .25W FC TC=-400/+800	01121	CB3335
A3R919	0683-3325	[redacted]	1	RESISTOR 3.3K 5% .25W FC TC=-400/+700	01121	CB3325
A3R920	0683-2715	6		RESISTOR 270 5% .25W FC TC=-400/+600	01121	CB2715
A3R921	0683-2205	[redacted]	1	RESISTOR [redacted] 5% .25W FC TC=-400/+500	01121	CB2205
A3R923	0698-3162	0	1	RESISTOR 46.4K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4642-F
A3R924	0698-3228	[redacted]		RESISTOR 49.9K 1% .125W F TC=0+-100	28480	0698-3228
A3R925	0683-1055	5	1	RESISTOR 1M 5% .25W FC TC=-800/+900	01121	CB1055
A3RT922	0837-0220	[redacted]		THERMISTOR-ROD TP 10K OHM	28480	0837-0220
A3T901	9100-4206	9	1	TRANSFORMER-POWER	28480	9100-4206
A3U901	1826-0544	0	1	V REF 8-DIP-C	04713	MC1403U
A3U902	1826-0138	[redacted]	1	IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N
A3U903	1820-1745	3	2	IC GATE CMOS [redacted] QUAD 2-INP	04713	MC14001BCP
A3U904	1820-1745	3		IC GATE CMOS NOR QUAD 2-INP	04713	MC14001BCP
A3U905	1820-2466	7	1	IC TIMER CMOS	32293	ICM7555IPA
A3W901	8120-3487	7	1	CONNECTOR-16-PIN SINGLE	28480	8120-3487
				OPT [redacted] MISCELLANEOUS PARTS		
	1420-0287	8	1	BATTERY RECHARGER-6V SLD	28480	1420-0287
	8120-3480	[redacted]	1	CABLE-LUGGED 125MM	28480	8120-3480
	8120-3481	[redacted]	1	CABLE-LUGGED 100MM	28480	8120-3481
				MISCELLANEOUS PARTS		
	03468-60201	5	1	ASSEMBLY-FRONT PANEL	28480	03468-60201
	03468-00601	3	1	SHIELD-PC (TOP)	28480	03468-00601
	5061-1166	6	1	DISPLAY-DRVR ASSY	28480	5061-1166
	7120-3530	[redacted]	1	LABEL-WARNING	28480	7120-3530
	7120-5370	[redacted]	1	PULL TO ROTATE LABEL	28480	7120-5370
	7120-8607	2	1	LABEL-METRIC [redacted]	28480	7120-8607
	7121-2420	7	1	SERIAL NUMBER, ETC.	28480	7121-2420
	7121-2446	7	1	OPERATION LABEL	28480	7121-2446

See introduction to this section for ordering information
*Indicates factory selected value

Table 5-4. [redacted] Mechanical and Miscellaneous Parts

Ref. Des.	Part Number	C D	Qty	Description
MP1	0370-0603	4	1	Pushbutton (Power Switch)
MP2	03468-60201	5	1	Front Panel Assembly
MP3	2360-0137	0	4	Screw
MP3	0900-0010	2	4	O Ring
MP4	7121-2446	5	1	Operation Label
MP5	5040-8058	5	1	Handle-Bail
MP6	03468-64401	5	1	Bottom Shell Assembly
MP7	4040-1126	3	1	Top Shell Assembly
MP8	5040-8044	9	4	Spacer Shell
MP9	2360-0209	7	1	Screw
MP10	03468-00601	3	1	Shield
MP11	2360-0117	6	3	Screw
MP12	4135-0415	2	1	Push Rod
MP13	0510-0585	9	4	Push-on Fastener
MP14	03468-00602	4	1	Bottom Shield
MP15	0624-0333	6	2	Screw
MP16	5001-1872	5	1	Display
MP17	0515-0226	5	2	Screw
MP18	0515-0067	2	2	Screw
MP19	03468-00101	8	1	Top Shield
MP20	03468-01201	1	1	Battery Cover





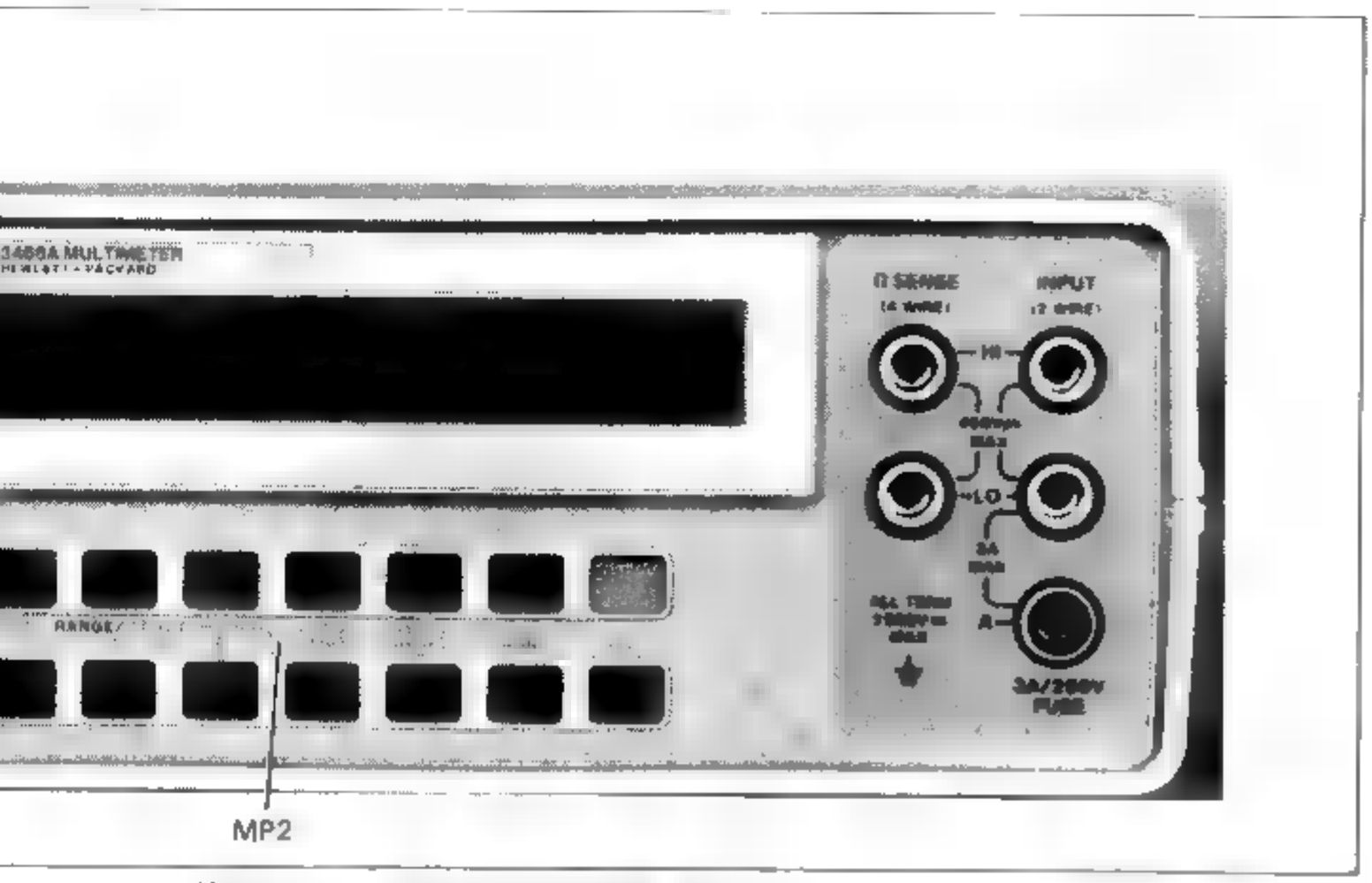


Figure 5-1. 3468A Front Panel View

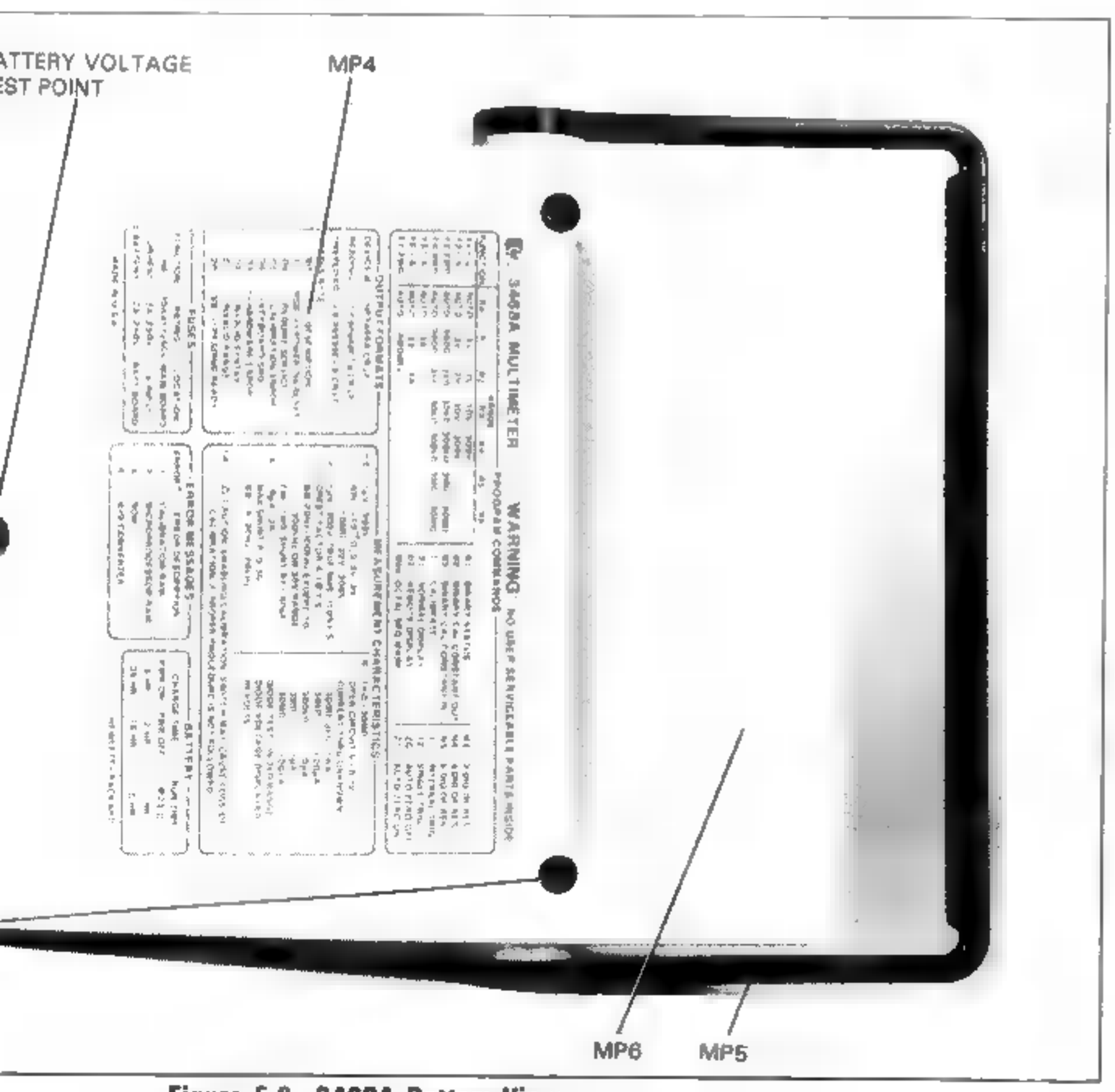
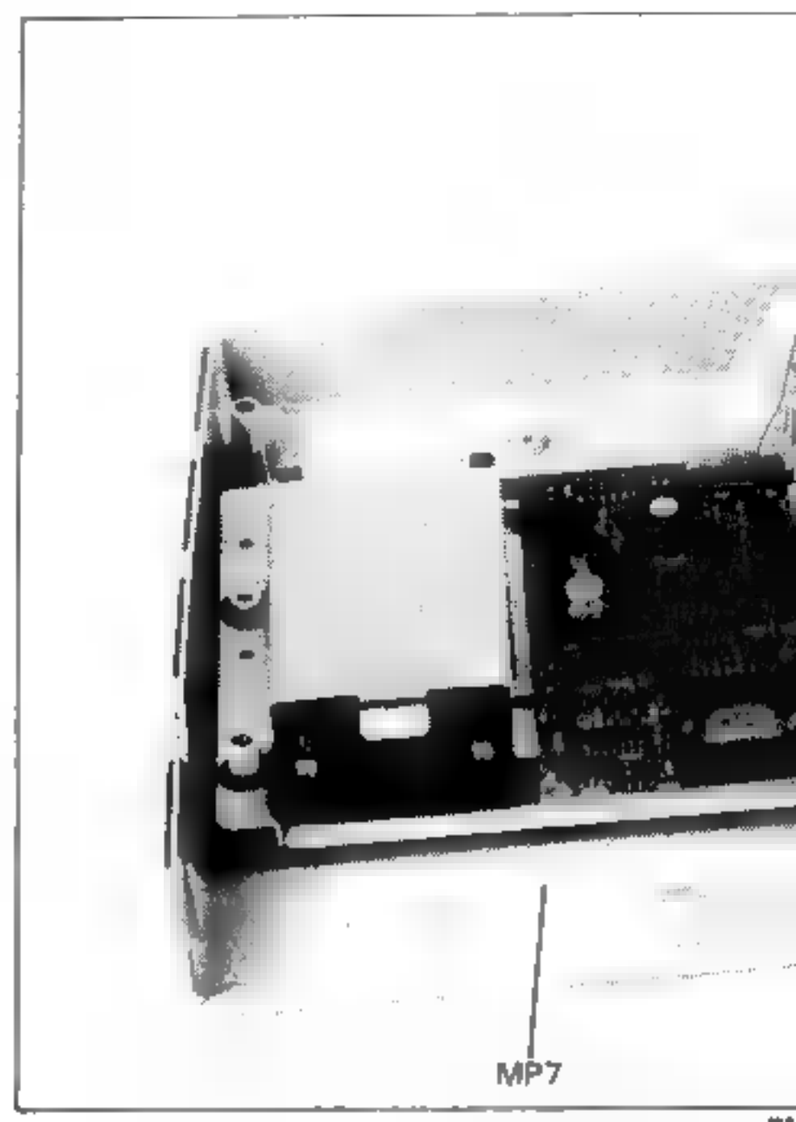


Figure 5-2. 3468A Bottom View



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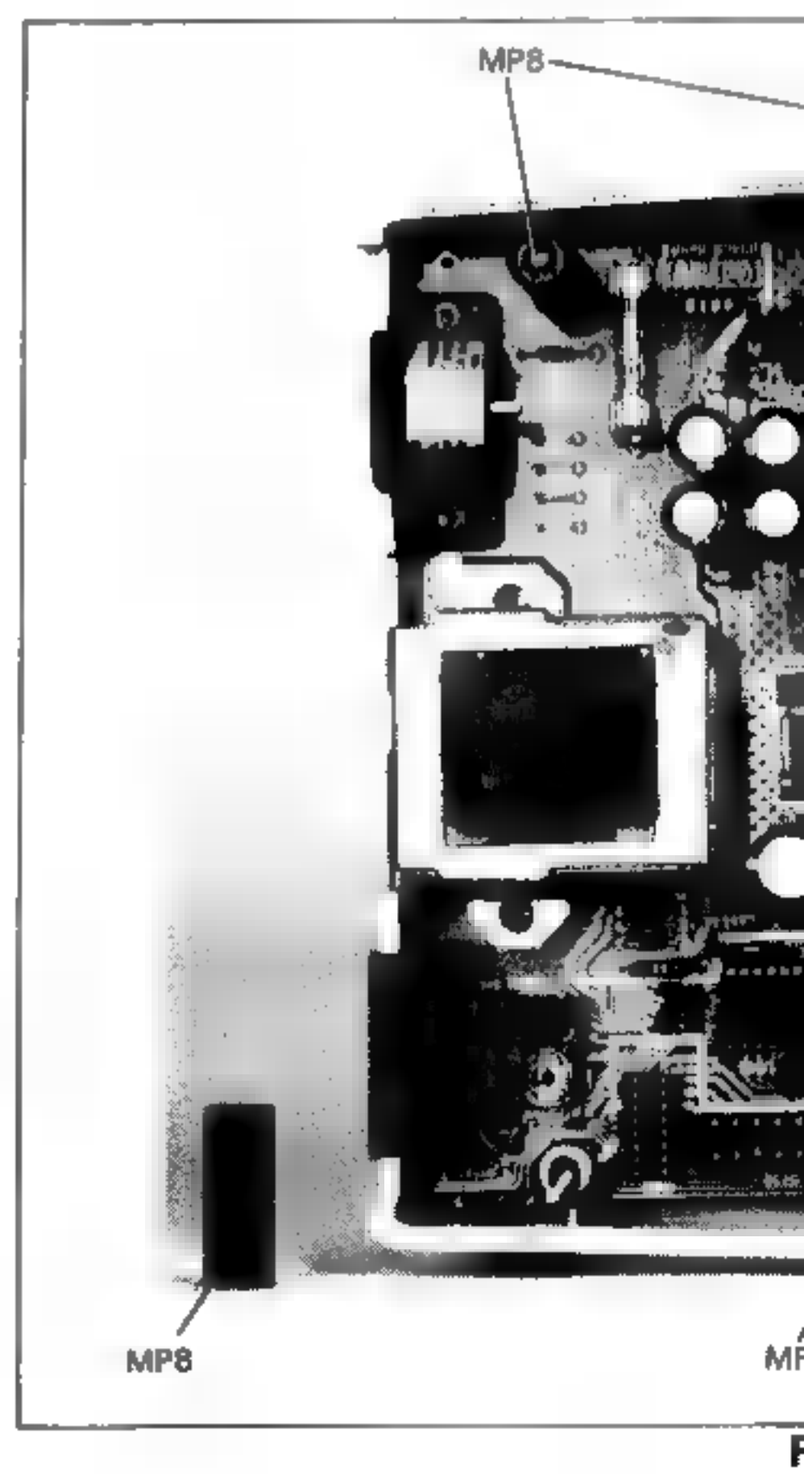

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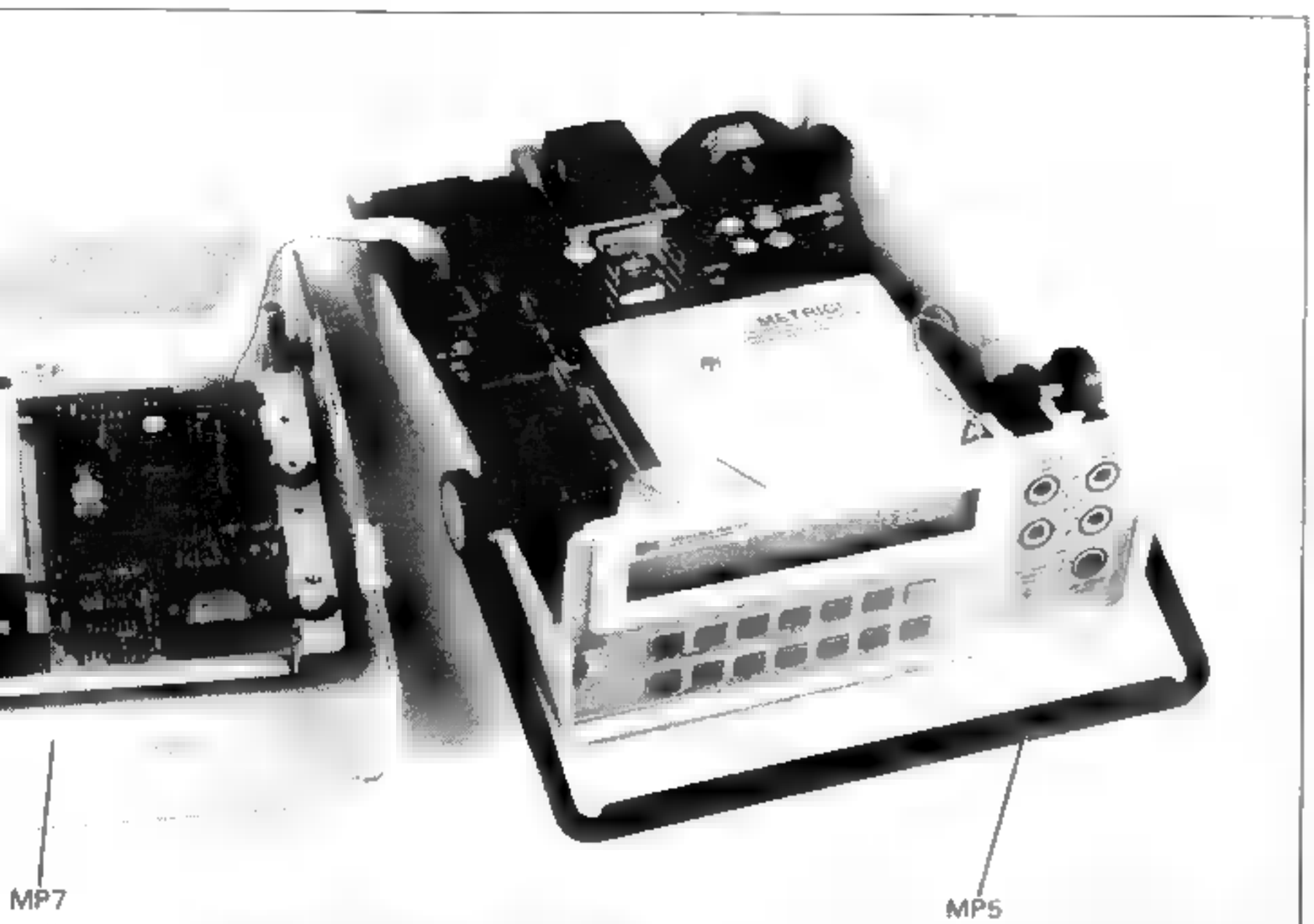


Figure 5-3. 3468A Inside View

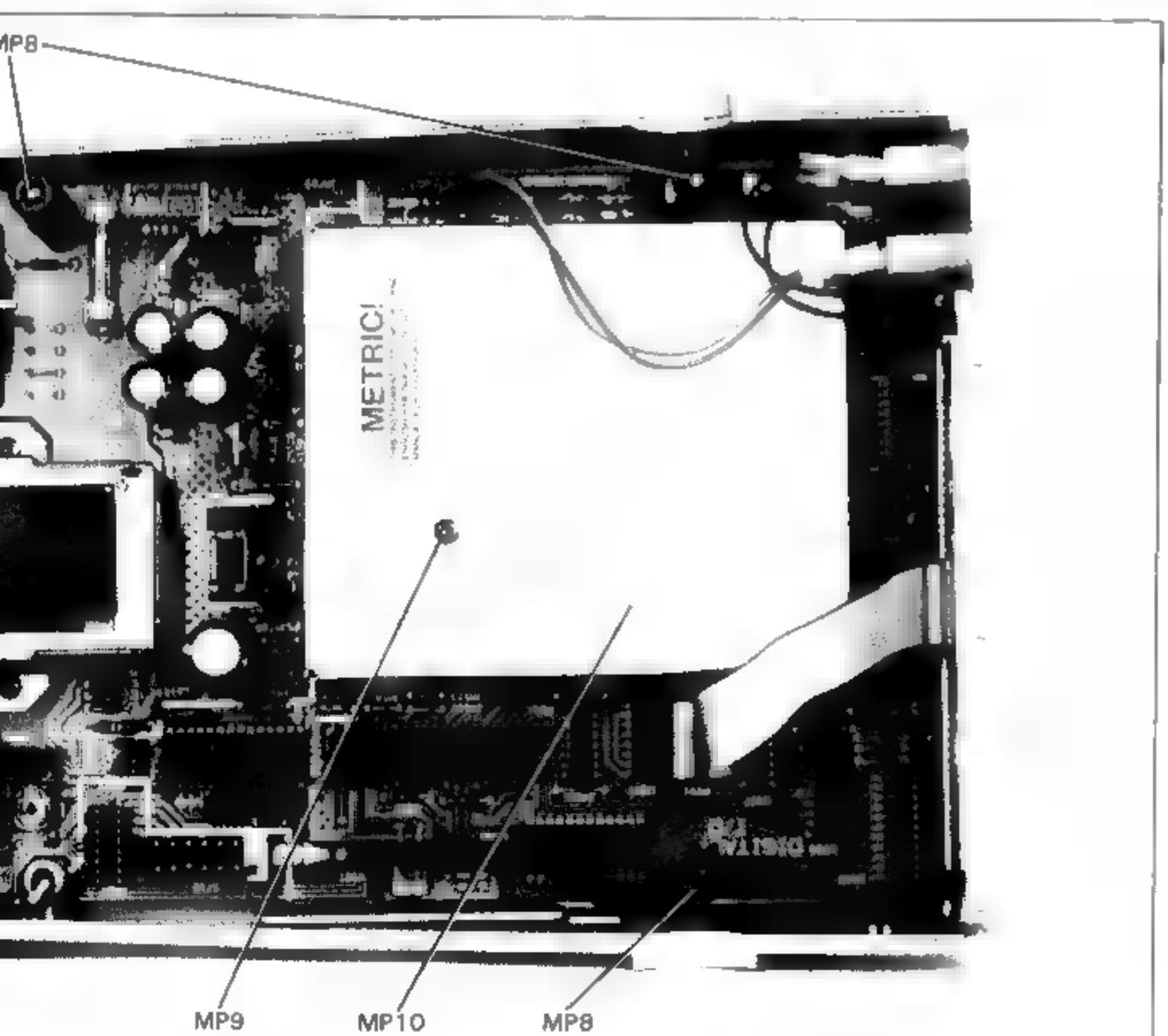


Figure 5-4. [redacted] Top View

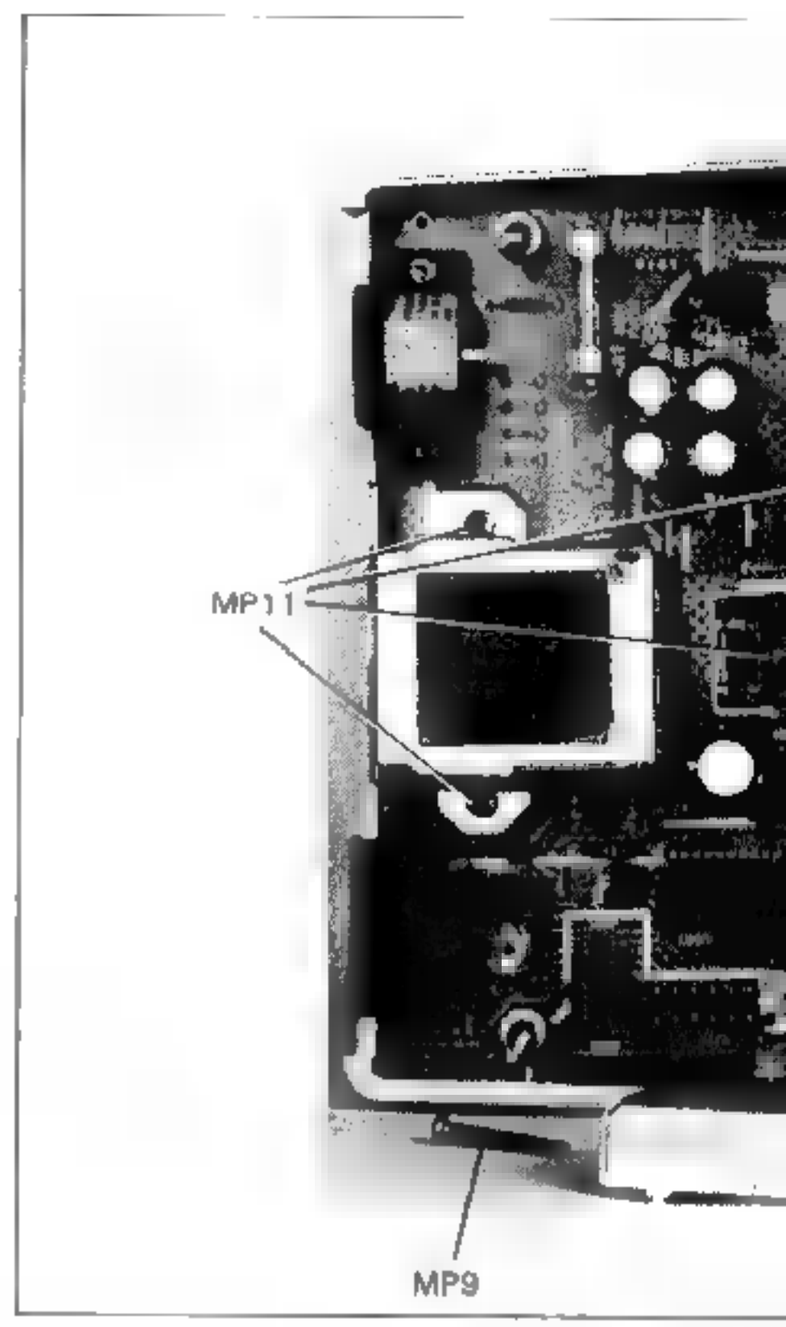
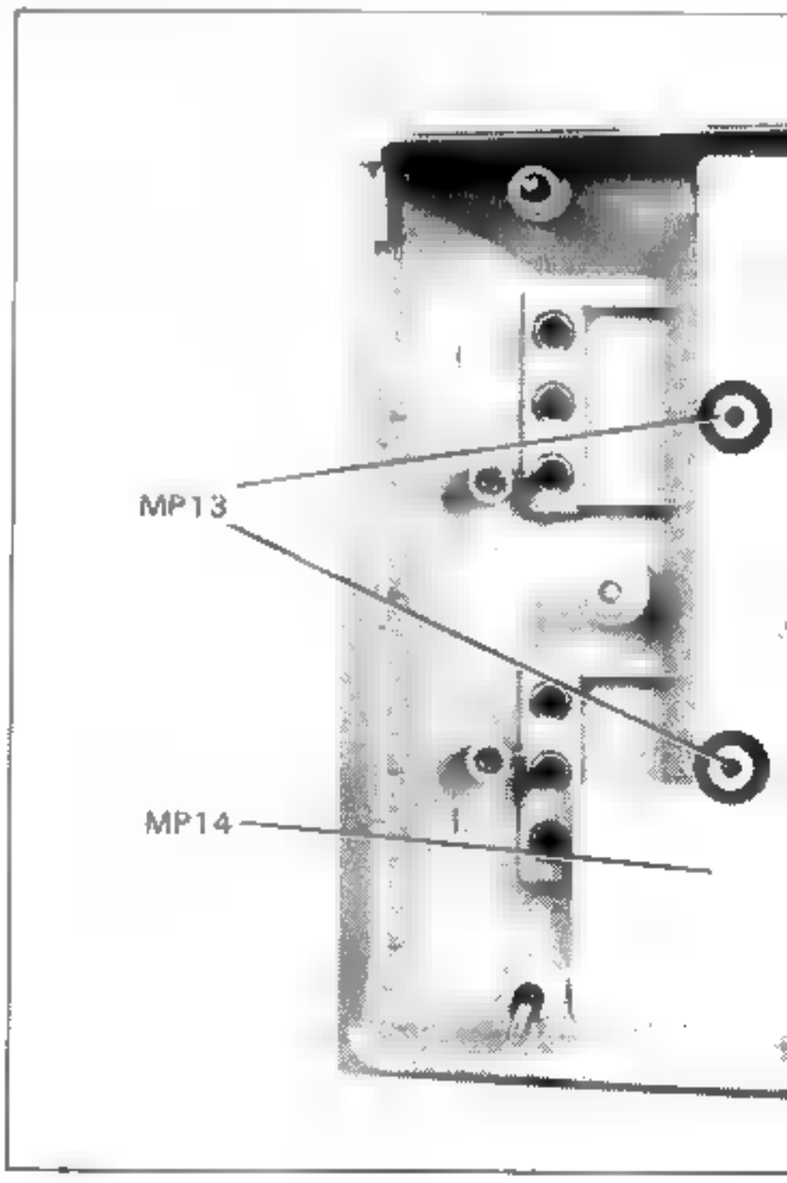


Figure 5-5.



Fig

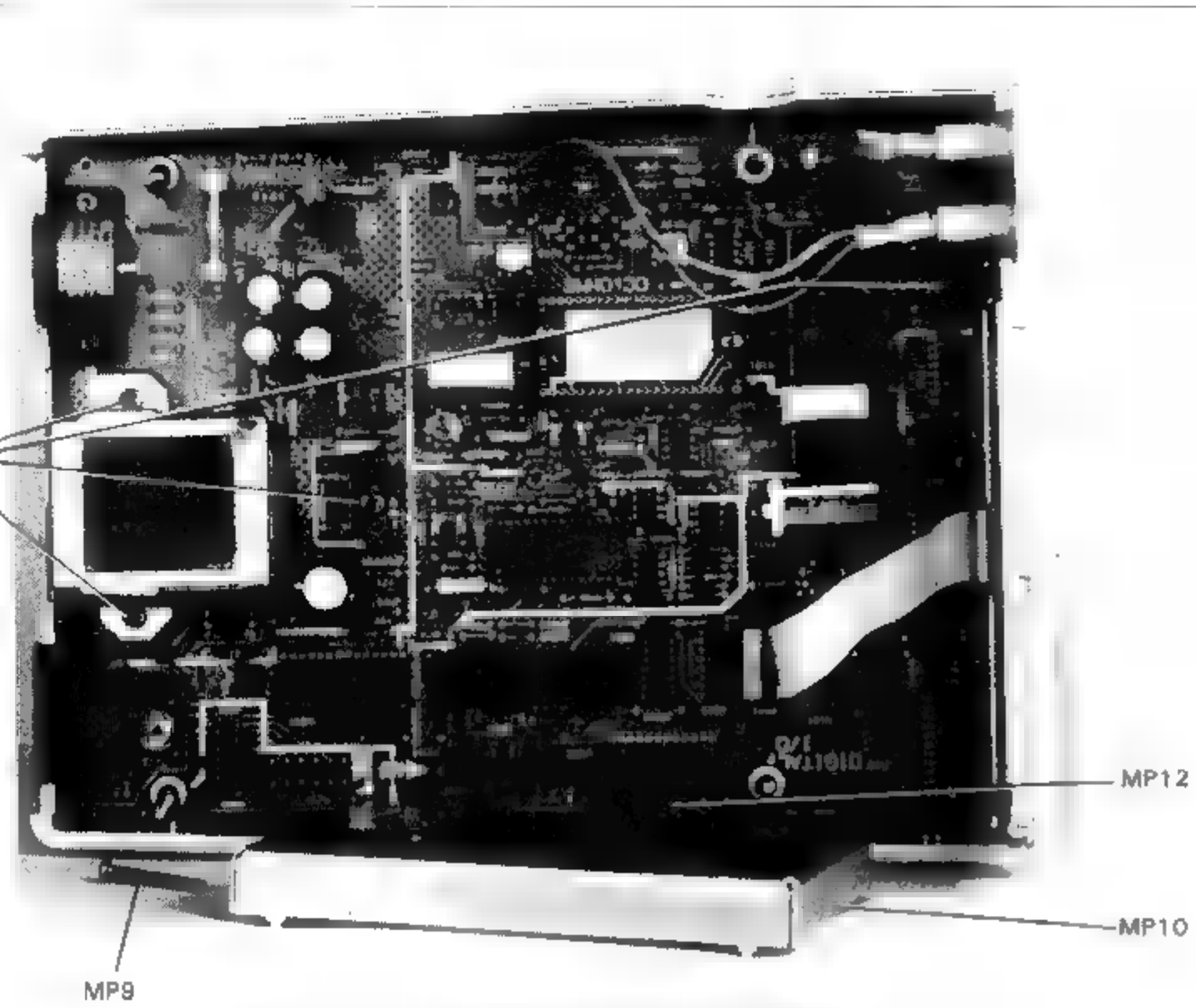


Figure 5-5. Top View with Inner Shield Removed

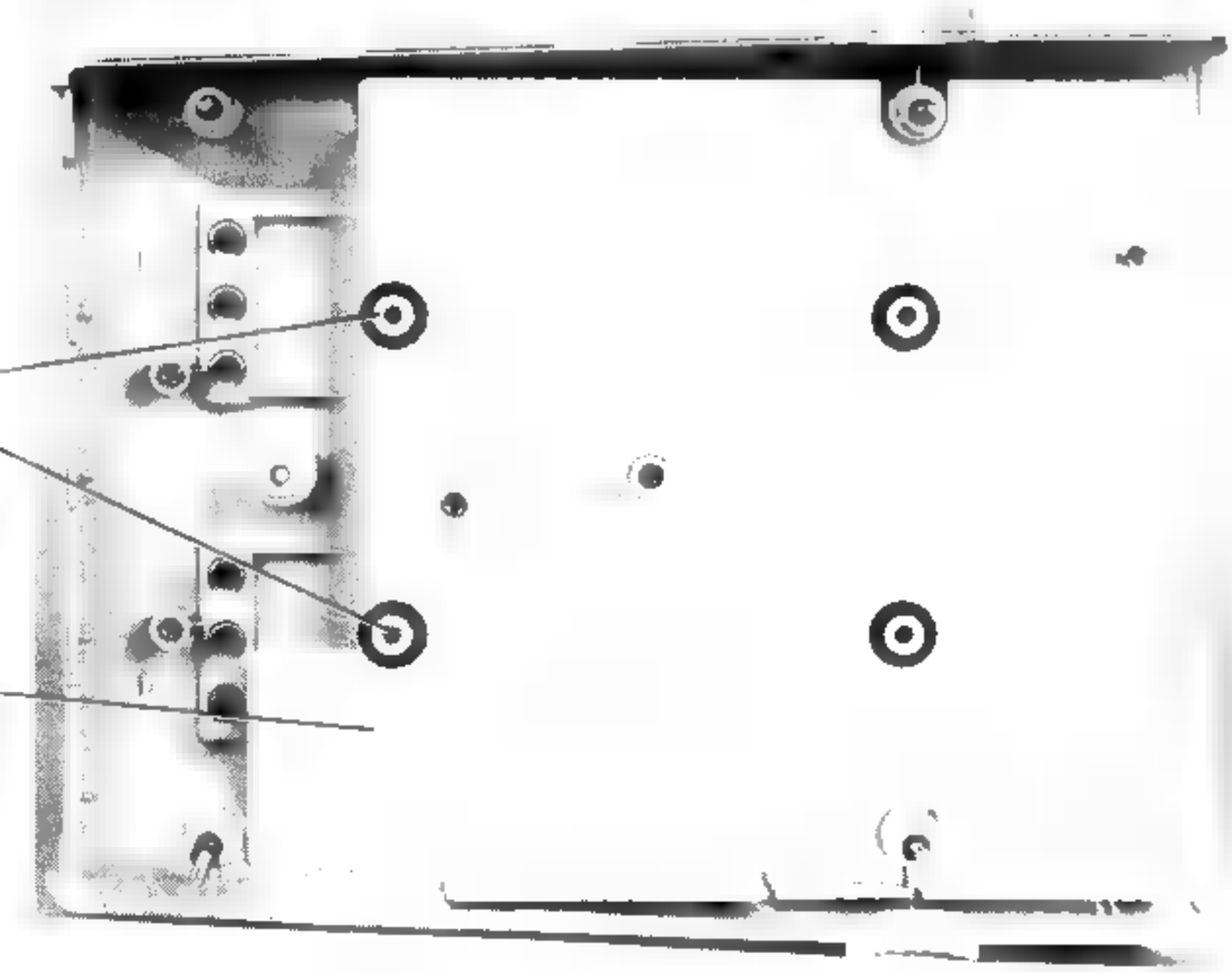
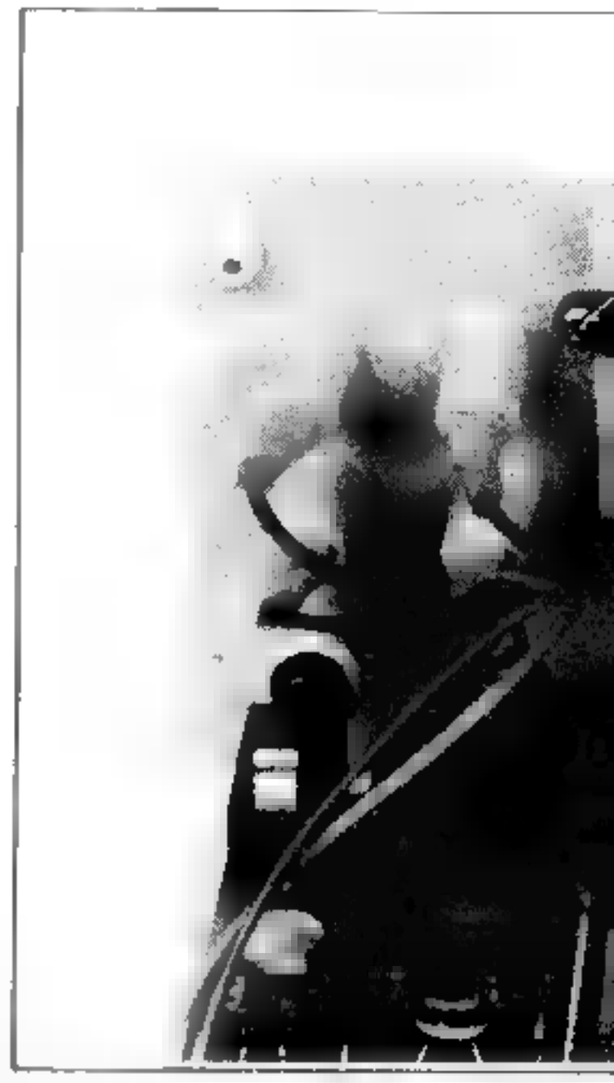
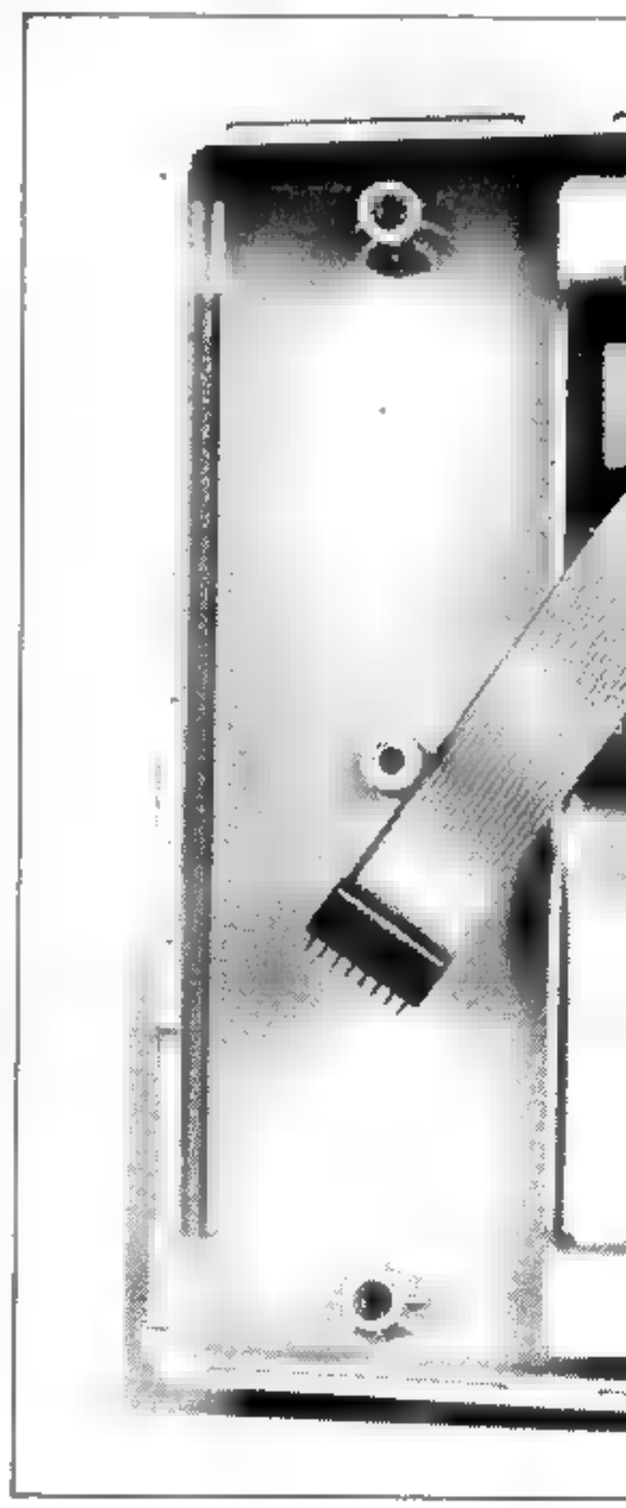


Figure 5-6. 3468A Bottom Cover





Figure

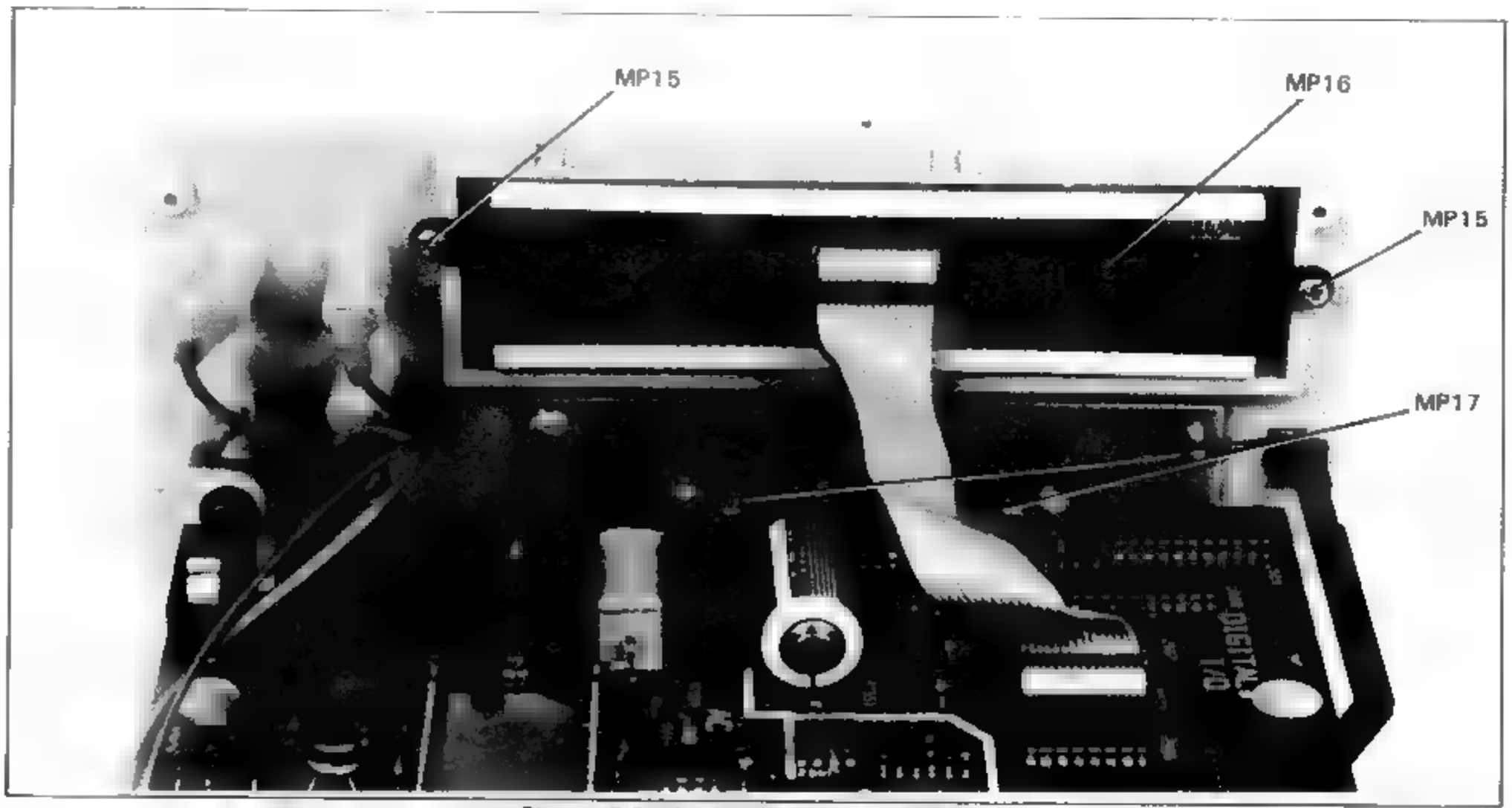


Figure 5-7. Front Panel Assembly View

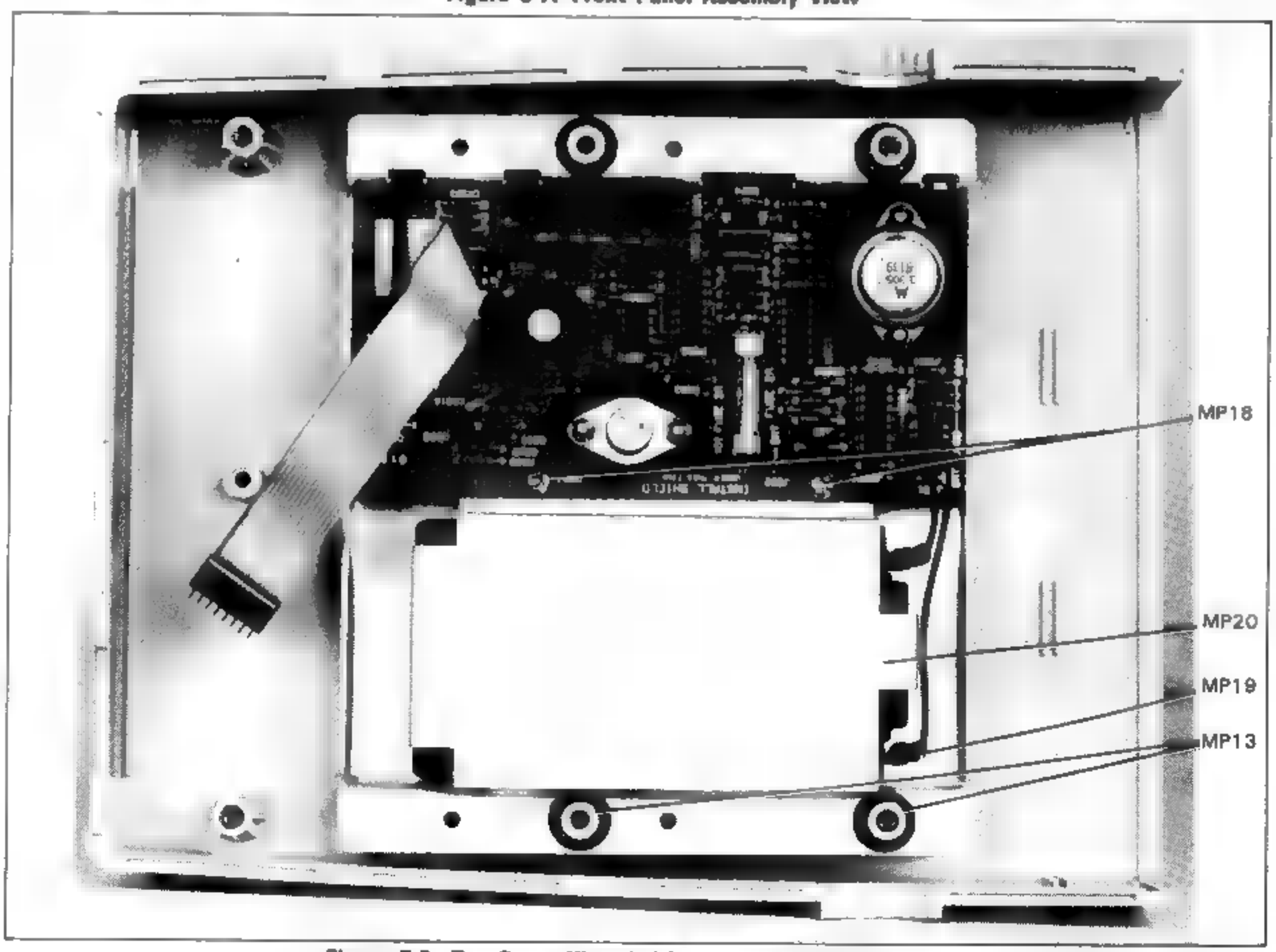


Figure 5-8. Top Cover View (with optional Battery Charger)

SECTION VI
BACKDATING

6-1. INTRODUCTION

6-2. This section has information which adapts this manual to instruments with serial numbers below the ones shown on the title page. Since this manual does directly apply to instruments having serial numbers listed on the title page, no change information is given here.

SECTION VII
SERVICE

7-1. INTRODUCTION

7-2. This section of the manual has information on how to troubleshoot and repair the 3468A multimeter with the information given in Service Groups. Preliminary troubleshooting procedures to select an appropriate group is also given in paragraph 7-24. It is recommended to use the procedures first, before going to a service group. Section VII also has the 3468A's complete Theory of Operation (in Service Group F), the complete Schematics (in Service Group G), and the necessary safety considerations. The section is separated as follows:

NOTE

The 3468A's Theory of Operation is in Service Group F (next to the last group).

a. Safety Considerations - paragraph 7-3.

b. Recommended Test Equipment - paragraph 7-8.

c. Miscellaneous Information - paragraph 7-10.

1. Instrument Disassembly (PC Board Replacement) - see Section V.

2. Fuse Replacement - paragraph 7-13.

d. Troubleshooting - paragraph 7-15.

1. Introduction - paragraph 7-16.

2. 3468A Self-Test - paragraph 7-18.

3. Service Group Selection - paragraph 7-24.

7-3. SAFETY CONSIDERATIONS

7-4. The 3468A has been designed with international safety standards. To maintain these standards, the cautions, warnings, and other safety related information in this manual must be followed when servicing the instrument. Servicing should only be done by qualified service personnel.

7-5. Calibration, maintenance, or repair of the instrument with covers removed while any power or voltage is applied, should be avoided as much as possible. If any work is done while power and/or voltage is applied, the work should be carried out by a skilled person who is aware of the hazards involved.

WARNING

Any interruptions of the protective grounding conductor (inside or outside the instrument) or disconnections of the protective earth terminal can make the instrument dangerous. Intentional interruption of the protective grounding conductor is strictly prohibited.

7-6. It is possible for capacitors inside the instrument to remain charged when the instrument has been turned off or its power source disconnected.

7-7. Make sure that only the recommended fuse type (fast blow, correct current rating, etc.) is used for replacement. The use of repaired fuses and the short-circuiting of fuse holders must be avoided.

WARNING

The service information given in this manual is normally used with the instrument's protective covers removed and with power applied. Voltage or signals at many points may, if contacted, result in personal injury.

7-8. RECOMMENDED TEST EQUIPMENT

7-9. The recommended test equipment is listed in Table 4-2 in Section IV of this manual.

7-10. MISCELLANEOUS INFORMATION

7-11. Instrument Disassembly (PC Board Replacement)

7-12. To replace the 3468A's main printed circuit board, the instrument must be completely disassembled. The procedure to disassemble the instrument is in Section V (Replaceable Parts) of this manual, which also has a procedure to replace the battery option board.

7-13. Fuse Replacement

7-14. The 3468A has two fuses plus an additional fuse for the battery option. One fuse is the main power fuse, another fuse is to protect the instrument in the DC and AC Current Functions, and the battery fuse is to protect the Battery Charger Circuitry. The main power fuse and the battery option fuse can only be replaced by remov-

ing the 3468A's top cover. Go to Section V of this manual for the disassembly procedure. The Amps Fuse is located inside the 3468A's A (Amps) terminal (on the front panel). To replace the fuse, first remove any cables connected to the A terminal and then turn the instrument off. Use the side slots on the A terminal to rotate the terminal counterclockwise. The terminal and fuse will then protrude from the front panel. Remove the terminal and fuse, and replace the fuse with a 3A at 250V fast blow fuse (-hp- Part No. 2110-0003). Return the terminal and fuse to the front panel.

7-15. TROUBLESHOOTING

CAUTION

The instrument contains CMOS Integrated Circuits which are susceptible to failure due to static discharge. It is especially important that grounded tools and wrist straps be used when handling or troubleshooting these components.

7-16. Introduction

7-17. The following paragraphs and Service Groups have troubleshooting information and procedures for the -hp- Model 3468A Digital Multimeter. Before troubleshooting and repairing the 3468A, make sure the failure is in the instrument rather than from any external connections. Also make sure the instrument is calibrated.

7-18. 3468A Self-Test

7-19. The 3468A Self-Test is designed to make sure that most of the instrument's internal logic circuitry is operational. The test is selected when the 3468A is first turned on or by pressing the blue Shift button and then the SGL/TRIG (TEST/RESET) button. The following paragraphs have the Self-Test Failures and some troubleshooting information.

7-20. Calibration RAM Error (ERROR 1). If this test fails, an attempt made to calibrate the RAM was unsuccessful. First try to calibrate the 3468A. If the failure is still noted, go to Service Group D, paragraph 7-D-12 to check the CMOS RAM.

7-21. RAM Error (ERROR 2). This test shows that the Main Controller's (U501) RAM has failed its internal self test. The failure is normally caused by a defective U501. To make sure U501 is the cause, go to Service Group D, paragraph 7-D-12, for further troubleshooting.

7-22. [illegible] Error (ERROR 4). This indicates that the 3468A has failed its internal ROM self test. The Control ROM (U502) is the most likely cause. Go to Service Group D, paragraph 7-D-23, for further troubleshooting.

7-23. A/D Converter Error (ERROR 8). This shows that the A/D Converter has failed its internal self test. Go to Service Group D, paragraph 7-D-32 (A/D Converter Troubleshooting) for troubleshooting.

7-24. Service Group Selection

Table 7-1. 3468A Service Groups

Service Group	Title
A	DC Volts and DC Current Troubleshooting
B	AC Volts and AC Current Troubleshooting
C	Ohms Troubleshooting
D	A/D Converter and Logic Troubleshooting
E	Miscellaneous Troubleshooting (Battery, etc.)
F	Theory of Operation
G	Schematics

7-25. The Service Groups have the Troubleshooting Information, Theory of Operation, and Schematics for the 3468A. Service Group F has the Theory of Operation and Service Group G has the Schematics. The rest of the groups have troubleshooting information.

7-26. The correct Service Group is selected according to failure. Once the failure has been determined, go to the recommended group. The following paragraphs lists possible failures, general troubleshooting information, and corresponding Service Group(s). The Service Groups are also listed in Table 7-1.

7-27. DC Volts and DC Current Failure (Service Group A). Typical DC Volts and DC Current Failures are Overload, Inaccurate, Constant Zero, Floating, or Noisy Readings. Troubleshooting information for these failures is in Service Group A. The following explains the failures.

a. **Overload.** An overload is caused when the reading taken by the instrument appears to be larger than the input actually is. This can be caused by a saturated DC/Ohms Input Amplifier or by the A/D Converter.

b. **Inaccurate Readings.** Inaccurate readings are normally caused when the measurement circuitry is not linear. This is because the 3468A is calibrated using zero and full scale inputs. Therefore, the full scale and zero readings must be good, but any other reading can be inaccurate.

c. **Constant Zero Reading.** A constant zero reading is normally caused when either the input to the DC/Ohms Input Amplifier or the input to the A/D Converter is shorted to ground (common). It can also be caused if no runup is done by the A/D Converter.

d. **Floating Reading.** A floating reading is when the 3468A displays a certain reading (with no input applied) which does not change, after an input is applied to the multimeter. This can be caused by the A/D Converter and if there is an open in the Input Circuitry.

e. **Noisy Readings.** Noisy readings can be caused by the Input Circuitry and A/D Converter.

7-28. AC Volts and AC Current Failures (Service Group B). AC Volts and AC Current Failures can be Overload, Inaccurate, Floating, or Noisy Readings. Troubleshooting information for these failures is in Service Group B. Before going to the service group, check and make sure the DC Volts and DC Current Function is operating correctly. The DC Volts and DC Current failures are explained in paragraph 7-27. The following explains the AC Volts and AC Current Failures.

a. **Overload.** An overload is caused when the reading taken by the instrument appears to be larger than the input actually is. This can be caused by a saturated AC to DC Converter or the A/D Converter.

b. **Inaccurate Readings.** Inaccurate readings are normally caused when the AC to DC Converter has poor frequency response.

c. **Floating Reading.** A floating reading is when the 3468A displays a certain reading (with no input applied) which does not change, after an input is applied to the multimeter. This can be caused if there is an open circuit in the AC to DC Converter or A/D Converter.

d. **Noisy Readings.** Noisy readings can be caused by the amplifiers and the RMS Converter in the AC to DC Converter.

7-29. Ohms Failures (Service Group C). Typical Ohms Failures can be Overload, Inaccurate, Floating, or Noisy Readings. Troubleshooting information for these failures is in Service Group C. Before going to the service group, check and make sure the DC Volts and DC Current Functions are operating correctly. The DC Volts and DC Current failures are explained in paragraph 7-27. The Ohms Failures are explained as follows:

a. **Overload.** An overload is caused when the reading taken by the instrument appears to be larger than the input actually is. This can be caused if the ohms current is too large. Since the DC/Ohms Input Amplifier or the A/D Converter can also cause an overload, make sure the DC Volts Function is operating correctly (go to paragraph 7-27, if the function fails).

b. **Inaccurate Readings.** Inaccurate ohms readings can be caused if the ohms current changes value under different loads. Inaccuracy can also be caused if the measurement circuitry is not linear. Make sure the DC Volts Function is operating correctly (go to paragraph 7-27, if the function fails).

c. **Constant Zero Reading.** A constant zero reading is normally caused when the Ohms Current Source does not supply any ohms current. The failure can also be caused when either the input to the DC/Ohms Input Amplifier or the input to the A/D Converter is shorted to ground (common). Make sure the DC Volts Function is operating correctly (go to paragraph 7-27, if the function fails).

d. **Floating Reading.** A floating reading is when the 3468A displays a certain reading (with no input applied) which does not change, after an input is applied to the multimeter. This can also be caused by the A/D Converter and the Input Circuitry. Since this is not an ohms failure, make sure the DC Volts Function is operating correctly (go to paragraph 7-27, if the function fails).

e. **Noisy Readings.** Noisy readings can be caused by a noisy ohms current.

7-30. Logic Failures (Service Group D). Logic Failures consists of Turn-On, Display, Keyboard, Control ROM, Calibration RAM (CMOS RAM), Processor RAM, and HP-IL Failures. Go to Service Group D, paragraph 7-D-12, if any of the failures are detected. The following explains the failures.

a. **Turn-On Failure.** A Turn-On Failure is when the 3468A's Keyboard, Display, and HP-IB is dead (i.e., the 3468A is completely inoperative). This is most likely caused by the Main Controller (U501) and associated circuitry.

b. **Inoperative Display.** An Inoperative Display is when part or all of the 3468A's display is inoperative. This can be caused by the display itself or the Main Controller Circuitry.

c. **Inoperative Keyboard.** An Inoperative Keyboard is when part or all of the 3468A's keyboard is inoperative. This can be caused by the keyboard itself or the Main Controller Circuitry.

d. **Control ROM Failure.** A failure caused by the Control ROM normally shows up as "ERROR 4" (after the 3468A's Self-Test). The ROM (U502) itself can be the cause in addition to the Main Controller (U501) and latch U508. A defective ROM can also show up as a Turn-On Failure.

e. **Processor RAM Failure.** This failure shows up as "ERROR 2" after the 3468A's Self-Test routine. It shows that the Main Controller's internal RAM has failed its self-test.

f. **Calibration RAM (CMOS RAM) Failure.** This failure can show up as a "ERROR 1" after the 3468A's

Self-Test routine. The RAM (U509) itself can be the cause or the Main Controller Circuitry.

g. **HP-IL (Remote) Failure.** This failure is most likely caused by the HP-IL Chip (U503), but can also be caused by other circuitry in the Chassis Common Logic Circuitry.

7-31. A/D Converter Failures (Service Group D). The A/D Converter Failures are normally caused by the A/D Converter itself or the Main Controller (U501). Go to Service Group D, paragraph 7-D-33 for troubleshooting. The following explains the failures.

a. **Overload, Constant Zero, Floating, or Noisy Readings.** Any one of these failures can be caused by the A/D Converter or the 3468A's Input Circuitry (Input Switching or DC/Ohms Input Amplifier). Since both circuitry can cause a failure, a procedure to isolate the circuitry is in both Service Group D and Group A. For a definition of the failures, go to paragraph 7-27 (DC Volts Failures).

b. **A/D Converter Fails.** This failure can be caused by the A/D Converter or the Main Controller. It shows up as "ERROR 8", after a Self-Test routine.

c. **Input Hybrid (U102) Failure.** Since the Input Hybrid receives its set-up information from the Main Controller, the controller can cause the hybrid to fail.

7-32. Miscellaneous Troubleshooting (Service Group E). Service Group E has some information on how to troubleshoot the 3468A's power supplies, Reference Circuitry, and the optional Battery Charger Circuitry. The Battery Charger Circuitry fails if the 3468A is unable to operate on its internal battery (i.e., the ac power source is disconnected).

SERVICE GROUP A

DC VOLTS AND DC CURRENT TROUBLESHOOTING

Service Group A Contents

Title	Paragraph
Introduction	7-A-1
Pre-Troubleshooting Information	7-A-3
DC Volts Troubleshooting	7-A-5
Overload, Floating, Constant Zero (with input applied), or Noisy Readings on All Ranges	7-A-7
Constant Zero Readings (with no input applied) on All Ranges	7-A-9
Overload, Constant Zero, Floating, or Noisy Readings on Some Ranges	7-A-11
Inaccurate Readings on All Ranges	7-A-17
Protection Circuitry Troubleshooting	7-A-19
Input Circuitry Troubleshooting	7-A-21
Overload Readings on All Ranges	7-A-23
Constant Zero Readings on All Ranges	7-A-25
Floating Readings on All Ranges	7-A-27
Noisy Readings on All Ranges	7-A-29
DC Current Troubleshooting	7-A-31

7-A-1. INTRODUCTION

7-A-2. This Service Group has the DC Volts and DC Current troubleshooting information for the 3468A. The Service Group is symptoms oriented (i.e., what fails) with two different levels of troubleshooting. The first level determines the general area of the 3468A that causes the failure and the second level has specific troubleshooting information for the area that fails. Unless otherwise specified, refer to Schematic 1 when using the troubleshooting procedures.

CAUTION

The instrument contains CMOS Integrated Circuits (e.g. U102) which are extremely susceptible to failures due to static discharge. It is especially important that grounded tools and wrist straps be used when handling or troubleshooting these components.

7-A-3. PRE-TROUBLESHOOTING INFORMATION

7-A-4. Before doing any troubleshooting procedures, perform the following:

a. Check the 3468A's Power Supplies and make sure they are stable, have the correct value, and are not oscillating. The power supplies are as follows (see Schematic 4):

Power Supply	Checked at	Voltage Level
+ 5V	Jumper + 5	+ 4.8 V to + 5.15V
− 15V	Jumper − 15	− 14.25V to − 15.75V
+ 15V	Jumper + 15	+ 14.55V to + 15.45V

b. Check and make sure the Reference Supplies are at the correct level and quiet. The + 10V supply can be checked at U405 pin 6, the -10V supply at U404 pin 6, and the buffered + 10V supply at JM201 (see Schematic 3).

7-A-5. DC VOLTS TROUBLESHOOTING

7-A-6. Typical DC Volts Failures are Overload, Inaccurate, Constant Zero, Floating, or Noisy Readings on all or some ranges. The following paragraphs have the failures and the troubleshooting procedures (see paragraph 7-27 for a description of these failures).

7-A-7. Overload, Floating, Constant Zero (with input applied), or Noisy Readings on All Ranges

7-A-8. If a failure is noted on all ranges, the failure can be caused by the Input Circuitry (Input Switching or DC/Ohms Input Amplifier) or by the A/D Converter. To determine the inoperative circuitry, do the procedure which follows this paragraph (the same procedure is also in Service Group D). If the procedure has been performed already, ignore the procedure and go to

paragraph 7-D-21 for troubleshooting. If it has not been performed, do the following:

a. Set the 3468A to the DC Volts Function and the 3V Range.

b. Turn Autozero off by pressing the blue Shift button and then the INT/TRIG (AUTOZERO) button.

c. Apply ■ stable +3V dc to the INPUT Terminals.

d. With a Digital Voltmeter (like the 3456A) measure for +10V at JM101.

e. Make sure the reading on the test voltmeter is a stable +10V. If the reading on the test voltmeter is a stable +10V, the A/D Converter is at fault. Go to Service Group D for troubleshooting.

f. If the reading on the test voltmeter is wrong (overload, constant zero, floating, or noisy), unsolder and lift the end of jumper JM101 which is connected to the A/D Converter (toward the front of the 3468A).

g. If the reading on the test voltmeter is now good, the A/D Converter is at fault. Go to Service Group D for troubleshooting.

h. If the reading is still wrong, the Input Circuitry (Input Switching and DC/Ohms Input Amplifier) is at fault. Go to paragraph 7-A-21 for troubleshooting.

i. Replace jumper JM101.

7-A-9. Constant Zero Readings (with ■ input applied) on All Ranges

7-A-10. Since the 3468A's 30V and 300V Ranges will normally have a constant zero reading with no input applied, the other ranges will also be at zero if relay K102 is shorted. Make sure the relay is good and is not being turned on by U102 (zero volts across the coil of K102). If the relay is turned on in the .3V and 3V Ranges, U102 may be defective.

7-A-11. Overload, Constant Zero, Floating, or Noisy Readings on Some Ranges

7-A-12. The Input Hybrid (U102) in conjunction with the Input Relays (K101 through K104) is used to select different paths to connect the input signals with the DC/Ohms Input Amplifier. The hybrid is also used to select the amplifier's different gain configurations. Because of this, ■ relay or U102 can make certain ranges fail.

7-A-13. Overload. An overload condition exists if the DC/Ohms Input Amplifier's feedback circuitry is open. Since the feedback circuitry is in U102, the hybrid is most likely defective.

7-A-14. Constant Zero Reading. The most likely cause is the Input Hybrid (U102).

7-A-15. Floating Readings. A floating reading is normally caused when an input path to the DC/Ohms Input Amplifier is open. Check for the following:

a. If the .3V and 3V Ranges are defective, do the following:

1. Short across the contacts of relay K101.

2. If the ranges are now good, make sure K101 ■ energized (5V dc across the coil). If K101 is energized, replace the relay. If not, U102 may be defective.

3. If, after replacing K101, the ranges still fail, U102 may be defective.

b. If the 30V and 300V Ranges are defective, do the following:

1. Short across the contacts of relay K102.

2. If the ranges are now good, make sure K102 is energized (5V dc across the coil). If K102 is energized, replace the relay. If not, U102 may be defective.

3. If, after replacing K102, the ranges still fail, U102 may be defective.

7-A-16. Noise. Noise can be caused by a FET switch internal to the Input Hybrid (U102) and U101. Replace U101 and then U102 if noise is noted on some ranges.

7-A-17. Inaccurate Readings ■ All Ranges

7-A-18. Inaccurate readings normally show up as other than positive full scale readings. This is because the 3468A is calibrated using zero and positive full scale (or 1/3 scale) inputs. Inaccurate readings can be caused by the Input Circuitry (Input Hybrid or DC/Ohms Input Amplifier). Try replacing U101 and then U102.

7-A-19. PROTECTION CIRCUITRY TROUBLESHOOTING

7-A-20. This circuitry consists of E101 and various diodes in U102. If all ranges fail, try replacing E101. If the ranges still fail or some ranges fail, the most likely cause is U102.

7-A-21. INPUT CIRCUITRY TROUBLESHOOTING

7-A-22. The Input Circuitry consists of the Input Switching Circuitry and the DC/Ohms Input Amplifier. Before troubleshooting the circuitry, make sure the

failure is not caused by the A/D Converter. Go to paragraph 7-A-5 to determine the faulty circuitry, if it has not been done already.

7-A-23. Overload Readings — All Ranges

7-A-24. An overload can be caused when the output of the DC/Ohms Input Amplifier is too high. This can be caused by an excessive input to the amplifier, open feedback, or a defective amplifier. Do the following:

a. Set the 3468A to the DC Volts Function and the 3V Range.

b. Make sure Autozero is turned off (see paragraph 7-A-8 step b).

c. Short the 3468A's INPUT Terminals.

d. With a high impedance Digital Voltmeter (like the 3456A) measure for zero volts (±1mV) at U101 pin 3 (U102 pin 10).

e. If the reading on the test voltmeter is other than zero volts (i.e., above 1 mV), the Input Hybrid is defective. Replace U102.

f. If the reading is good, connect pin 6 and pin 2 (U102 pin 3 and 9) of U101 to each other. Using the test voltmeter, measure for zero volts (±3mV) at pin 6 of U101.

g. If the reading is good (less than ±3mV), the amplifier feedback circuitry is defective. Replace U102.

h. If the reading is wrong (greater than 3mV), the amplifier is defective. Replace U101.

7-A-25. Constant Zero Readings on All Ranges

7-A-26. A constant zero reading is normally caused when the input or output of the DC/Ohms Input Amplifier is shorted to ground. Make sure pin 1 and pin 13 of U102 and pin 6 of U101 are not shorting to ground. If no shorts are noted, do the following:

a. Set the 3468A to the DC Volts Function and the 3V Range.

b. Make sure Autozero is turned off (see paragraph 7-A-8 step b).

c. Using an external power supply with a 100K ohm resistor in series, apply +3V to pin 3 of U101. (Connect one end of the resistor to pin 3 of U101 and the other end to the power supply.)

d. Using a high impedance Digital Voltmeter (like the 3456A), make sure the voltage at the resistor end connected to pin 3 of U101 is +3V.

e. If the voltage is loaded down, the Input Hybrid is defective. Replace U102.

f. If the voltage is +3V, measure (using the test voltmeter) for approximately +10V at U101 pin 6.

g. If the voltage is incorrect, the Input Amplifier is at fault. Replace U101.

h. If the voltage is good, the Input Hybrid (U102) may be defective.

7-A-27. Floating Reading on All Ranges

7-A-28. A floating reading is normally caused when an open exists between the DC/Ohms Input Amplifier and the instrument's INPUT Terminals. Before troubleshooting the instrument, make sure the wires from the INPUT Terminals to the mother board are good. If they are good, do the following:

a. Set the 3468A to the DC Volts Function and the 3V Range.

b. Make sure Autozero is turned off (see paragraph 7-A-8 step b).

c. Using an external power supply, apply +3V to the 3468A's INPUT Terminals.

d. Connect the 3468A's HI INPUT Terminal to U101 pin 3 (U102 pin 10).

e. If the displayed reading on the 3468A is still a floating reading, replace U101.

f. If the displayed reading on the 3468A is +3V, the Input Hybrid (U102) may be at fault.

7-A-29. Noisy Readings — All Ranges

7-A-30. Noisy readings can be caused by the Input Hybrid or the DC/Ohms Input Amplifer. Do the following:

a. Set the 3468A to the DC Volts Function and the 3V Range.

b. Make sure Autozero is turned off (see paragraph 7-A-8 step b).

c. If the reading on the 3468A is quiet with Autozero off, the Input Hybrid is defective. Replace U102. If the reading is still noisy, continue with the next step.

d. Connect pin 6 and pin 2 (U102 pin 3 and 9) of U101 to each other.

e. Apply a stable +3V to the 3468A's INPUT Terminals.

f. Using a high impedance Digital Voltmeter (like the 3456A) measure for ■ stable +3V at U101 pin 3.

g. If the voltage is noisy, replace the Input Hybrid (U102).

h. If the voltage is stable, measure for ■ stable +3V at pin 6 of U101.

i. If the voltage is noisy, replace U101. If the voltage is stable, replace U102 (Input Hybrid).

7-A-31. DC CURRENT TROUBLESHOOTING

7-A-32. Make sure the DC Volts Function is operating correctly on all ranges, before troubleshooting for dc current failures. Go to paragraph 7-A-5 to troubleshoot for DC Volts Failures. If the DC Volts Function is good, the only components that can cause a current failure are an open current fuse (F101), a defective resistor R107, or the Input Hybrid U102. Make sure F101 and R107 are good. If the resistor and fuse are good, U102 may be defective.

SERVICE GROUP B
AC VOLTS AND AC CURRENT TROUBLESHOOTING

Service Group B Contents

Title	Paragraph
Introduction	7-B-1
AC Volts Troubleshooting	7-B-3
Overload, Floating, or Noisy Readings on All Ranges	7-B-5
Inaccurate Readings on All Ranges	7-B-8
Overload, Inaccurate, Floating or Noisy Readings on Some Ranges	7-B-10
AC Current Troubleshooting	7-B-12
Overload Protection Circuitry Troubleshooting	7-B-14

7-B-1. INTRODUCTION

7-B-2. This Service Group has the AC Volts and AC Current troubleshooting information for the 3468A and is symptoms oriented (i.e., what fails). Before troubleshooting for AC Volts or AC Current Failures, make sure the 3468A's DC Volts and DC Current Functions are operating correctly (go to Service Group A, if the functions fail). These functions must be good, before the AC Volts and AC Current Functions can operate.

CAUTION

The instrument contains CMOS Integrated Circuits (e.g. U102) which are extremely susceptible to failures due to static discharge. It is especially important that grounded tools and wrist straps be used when handling or troubleshooting these components.

7-B-3. AC VOLTS TROUBLESHOOTING

7-B-4. An AC Volts Failure can be Overload, Inaccurate, Floating, or Noisy Readings on all or some ranges. The following paragraphs have the failures and troubleshooting procedures (go to paragraph 7-28 for a description of these failures). Unless otherwise specified, refer to Schematic 2 for the following troubleshooting procedures.

7-B-5. Overload, Floating, or Noisy Readings on All Ranges

7-B-6. An overload reading can be caused if one of the amplifiers or the RMS Converter in the AC to DC Converter is saturated. A floating reading can be caused if there is an open circuit in the AC to DC Converter. Noisy readings can be caused by any of the amplifiers in the converter, or by faulty bypass capacitors.

7-B-7. Before troubleshooting the AC to DC Converter, make sure relay K104 (see Schematic 1) is good and is energized (5V dc across the coil). If the relay is not energized, U102 may be defective. If K104 is good, do the following procedure.

a. Set the 3468A to the AC Volts Function and the 3V Range.

b. Apply a stable 3V at 1KHz sine wave to the 3468A's INPUT Terminals.

c. Using a stable Digital Voltmeter (like the 3456A), measure for approximately +3V dc at jumper JM302.

d. If the reading is ■ stable +3V dc, do the following:

1. Apply 1V at 1KHz to the INPUT Terminals.

2. If the test voltmeter now reads a stable +1V dc at JM302, the AC to DC Converter is good. Make sure the DC Volts Function is operating correctly.

3. If the DC Volts Function is good, replace the A/D Hybrid (U403).

e. If the reading is other than approximately +3V or noisy, measure for approximately .12V ac at jumper JM303. Make sure the reading on the test voltmeter is stable.

f. If the reading is good, do the following:

1. Measure for a stable 3V ac at pin 4 of U303.

2. If the reading is good, replace U303.

3. If the reading is wrong, lift the end of

capacitor C304 which is connected to pin 4 of U303. Then measure for a stable 3V ac at the lifted end of the capacitor.

4. If the voltage is good, replace U303.

5. If the voltage is still wrong, make sure the voltage at pin 6 of U302 is ■ good stable 3V ac.

6. If the voltage is good, capacitor C304 or C306 is defective.

7. If the voltage is unstable or wrong, connect pin 6 to pin 2 of U302 (use ■ very short lead to connect the pins, to prevent oscillations). If the reading at pin 6 is now a stable .12V, the feedback resistors of U302 are defective. If the .12V is wrong, replace U302.

g. If the reading at JM303 is other than .12V ac or unstable, replace U301. If the AC Volts Function is still inoperative, U102 may be defective.

7-B-8. Inaccurate Readings on All Ranges

7-B-9. Since the 3468A's AC to DC Converter is calibrated with an input voltage at a frequency of 1KHz, inaccuracy can result from poor frequency response. Since the high frequency is compensated by C302 or C305,make sure the capacitors are good. If the capacitors are good, try replacing U301 and if still inaccurate, try U102.

7-B-10. Overload, Inaccurate, Floating, ■ Noisy Readings ■ Some Ranges

7-B-11. Since all ranging of the AC to DC Converter is done in the Input Hybrid U102, the hybrid is the most likely cause for ac failures on some ranges.

7-B-12. AC CURRENT TROUBLESHOOTING

7-B-13. Make sure the DC Current and AC Volts Functions are operating correctly on all ranges, before troubleshooting for ac current failures. Go to paragraph 7-B-3 to troubleshoot the AC Volts Failures and Service Group A for the DC Current Failures. If the functions are good, the only component that can cause a failure is the Input Hybrid U102.

7-B-14. OVERLOAD PROTECTION CIRCUITRY TROUBLESHOOTING

7-B-15. All of the ac functions overload protection circuitry is in U102. Replace the hybrid, if defective.

SERVICE GROUP C
OHMS TROUBLESHOOTING

Service Group C Contents

Title	Paragraph
Introduction	7-C-1
2-Wire and 4-Wire Ohms Troubleshooting	7-C-4
Overload Readings on All Ranges	7-C-6
Inaccurate Readings on All or Some Ranges	7-C-8
Constant Zero Reading on All Ranges	7-C-10
Noise on All Ranges	7-C-12
Floating Readings on All or Some Ranges	7-C-14
Overload, Noise, or Constant Zero Readings ▬ Some Ranges	7-C-16
Ohms Protection Circuitry Troubleshooting	7-C-18
Ohms Current Source Troubleshooting	7-C-20
4-Wire Ohms Troubleshooting	7-C-22

7-C-1. INTRODUCTION

7-C-2. This Service Group has the Ohms troubleshooting information for the 3468A and is symptoms oriented (i.e., what fails). Unless otherwise specified, refer to Schematic 1 when using the troubleshooting procedures.

7-C-3. Most ohms failures will show up in both the 2-Wire and 4-Wire Ohms Function with the troubleshooting procedure given in paragraph 7-C-4. If a failure shows up in only the 4-Wire Ohms Function, go to paragraph 7-C-22 for troubleshooting.

CAUTION

The instrument contains CMOS Integrated Circuits (e.g. U102) which are extremely susceptible to failures due to static discharge. It is especially important that grounded tools and wrist straps be used when handling or troubleshooting these components.

7-C-4. 2-WIRE AND 4-WIRE OHMS TROUBLESHOOTING

7-C-5. An Ohms Failure can be Overload, Inaccurate, Constant Zero, Floating, or Noisy Readings on some or all ranges. A failure should show up with an appropriate input applied to the 3468A. For example, an overload failure on the 3K ohm Range should show up with a 3K ohm resistor applied to the input. The following paragraphs have the ohms failures and the troubleshooting procedures (go to paragraph 7-29 for a description of the failures).

7-C-6. Overload Readings on All Ranges

7-C-7. An Overload is normally caused by a high ohms current (or an open between the INPUT Terminals and the Input Circuitry). Make sure the DC Volts Function is operating correctly before troubleshooting for an ohms failure. Do the following procedure.

a. Set the 3468A to the 2-Wire Ohms Function and the 3K ohm Range.

b. Connect a 3K ohm Resistor to the 3468A's INPUT Terminals.

c. Using a high impedance Digital Voltmeter (like the 3456A), measure the voltage between pin 17 and pin 19 of U102. Connect the low input of the voltmeter to pin 17 and the high input to pin 19.

d. If the reading on the test voltmeter is +4V dc and the 3468A displays an overload, the Range Resistors in U102 may be too low. Replace U102.

e. If the reading is other than +4V dc, the Ohms Current Source is defective. Go to paragraph 7-C-20 for troubleshooting.

7-C-8. Inaccurate Readings on All ▬ Some Ranges

7-C-9. This failure is normally caused when the ohms current changes value due to ▪ load change. Do the following procedure.

a. Set the 3468A to the 2-Wire Ohms Function and the 3K ohm Range.

b. Connect a 3K ohm Resistor to the 3468A's INPUT Terminals.

c. Using a high impedance Digital Voltmeter (like the 3456A), measure the voltage across R204. Since the ohms current on the 3K ohm Range is 1mA, the voltage should be approximately .47V dc.

d. If the voltage is radically wrong, the ohms current is incorrect. Use the overload troubleshooting procedure (in paragraph 7-C-6) to determine the faulty circuitry.

e. If the voltage is good, remove the 3K ohm Resistor from the INPUT Terminals. Then short the INPUT Terminals.

f. If the voltage across R204 changes, the Output PMOS FET in U102 or the Ohms Protection Circuitry may be defective. Make sure Q201 through Q205 are good. If they are, replace U102.

7-C-10. Constant Zero Reading on All Ranges

7-C-11. A Constant Zero Reading is normally caused when the ohms Current Source supplies no ohms current (current at zero value). Since no current goes through the resistor to be measured, no voltage drop across the resistor is developed and the 3468A measures zero volts (zero reading). A no-current condition can be caused by an open circuit between the Ohms Current Source and The INPUT Terminals, or by a defective Current Source. Do the following procedure.

a. Set the 3468A to the 2-Wire Ohms Function and the 3K ohm Range.

b. Connect a 3K ohm Resistor to the 3468A's INPUT Terminals.

c. Using a clip lead, connect pin 15 of U102 to the 3468A's HI INPUT Terminal.

d. If the 3468A still shows a constant zero reading, the Ohms Current Source is inoperative. Go to paragraph 7-C-20 for troubleshooting.

e. If the Ohms Function is now operating correctly, do the following:

1. Disconnect the clip from the HI INPUT Terminal and connect it to the collector of Q204 (junction of Q204, R203, and anode of CR201). Leave the other end of the clip lead connected to pin 15 of U102 for the checks that follow.

2. If the Ohms Function is now inoperative, check for an open Q201 through Q204.

3. If the Ohms Function is still operating, disconnect the clip lead from Q204 and connect it to the cathode of CR201.

4. If the function is now inoperative, check for an open CR201.

5. If the function is still operating, check for an open K103, R204, or L201. Make sure K103 is energized (+5V across the relay coil), before replacing the relay. If the relay is not energized, U102 may be defective.

7-C-12. Noise on All Ranges

7-C-13. Noise on all ranges is normally caused by a noisy ohms current. Do the following procedure.

a. Set the 3468A to the 2-Wire Ohms Function and the 3K ohm Range.

b. Connect a 3K ohm Resistor to the 3468A's INPUT Terminals.

c. Using a clip lead, connect pin 15 of U102 to the 3468A's HI INPUT Terminal.

d. If the Ohms Function is quiet, noise is caused by the Ohms Protection Circuitry. Check Q201 through Q204.

e. If the Ohms Function is still noisy, check the following:

1. Using a high impedance Digital Voltmeter (like the 3456A), make sure the voltage at U201 pin 6 is a quiet +12V (<10uV change). Replace U201, if noisy. If the voltage is still noisy, try U102.

2. If the voltage at U201 pin 6 is good, measure for a quiet +12V at U202 pin 6 (<10uV change). Replace U202, if noisy. If the voltage is still noisy, replace U102.

3. If the voltage at U202 pin 6 is good, replace U203. If the ohms function is still noisy, replace U102.

7-C-14. Floating Reading on All or Some Ranges

7-C-15. A Floating Reading is normally caused by an open circuit between the INPUT Terminals and the DC/Ohms Input Amplifier. Make sure the DC Volts Function is operating correctly, before suspecting an ohms failure. If the failure shows up in the Ohms Function only, U102 may be defective.

7-C-16. Overload, Noise, or Constant Zero Readings on Some Ranges

7-C-17. Failures on some ranges can only be caused by the Input Hybrid U102. This is because the hybrid is used to configure the current source for the different

ranges. If at least one range is good, the Ohms Current Source is operating.

7-C-18. [redacted] PROTECTION CIRCUITRY TROUBLESHOOTING

7-C-19. The Ohms Protection Circuitry is used to protect the Ohms Current Source from excessive positive or negative input voltages. To make sure the circuitry is operational, check the following:

a. To check the circuitry operation for positive input voltages, do the following:

1. Set the 3468A to the 2-Wire Ohms Function and the 3K ohm Range.

2. Connect a 1K ohm resistor from pin 15 of U102 to ground (positive side of capacitor C313).

3. Connect a high impedance Digital Voltmeter (like the 3456A) across the 1K ohm resistor.

4. Acquire a variable 0-10V power supply. Set the supply for a 0V output and connect it to the 3468A's INPUT Terminals.

5. Measure for approximately 1V dc across the 1K ohm resistor. If the voltage is wrong, the Current Source may be defective (go to paragraph 7-C-20 for troubleshooting).

6. Adjust the power supply until it outputs +10V. If the voltage across the 1K ohm resistor remains at approximately +1V, the Ohms Protection Circuitry does protect from positive input voltages.

7. If the voltage does not remain at +1V, replace CR201.

b. To check the circuitry operation for negative input voltages, do the following:

1. Leave the same set up as in step a, except bring the variable power supply down to 0V. The voltage across the 1K ohm resistor should again be +1V.

2. Reverse the power supply output leads and apply -10V dc to the 3468A's INPUT Terminals.

3. The voltage across the 1K ohm resistor should go down to approximately zero volts or some positive voltage.

4. If the voltage is good, the Ohms Protection Circuitry is operating correctly.

5. If the voltage changes polarity (negative voltage), the Ohms Protection Circuitry is inoperative. Measure for approximately -.6V at the source and drain of Q205. If the voltage is high or zero, replace Q205. If the voltage is good, check for a defective Q201 through Q204.

7-C-20. OHMS CURRENT SOURCE TROUBLESHOOTING

7-C-21. The Ohms Current Source consists of a Voltage Reference, Buffer and Range Resistors, and a Gate Bias Amplifier. Before troubleshooting the current source, make sure the +10V reference is good at JM201. To troubleshoot the Ohms Current Source, do the following procedure.

a. Set the 3468A to the 2-Wire Ohms Function and the 3K ohm Range.

b. Using a high impedance Digital Voltmeter (like the 3456A), measure the voltage at pin 2 and pin 3 of U203 (U102 pins 17 and 18, respectively). Make sure the voltage on both pins is approximately +8V.

c. If the voltages are not approximately the same, replace U203.

d. If the voltages on both pins are wrong (other than +8V), but are approximately the same, do the following:

1. Measure for approximately +12V at pin 6 of U201.

2. If the voltage at pin 6 of U201 is +12V, replace U102.

3. If the voltage at pin 6 of U201 is other than +12V, measure for approximately +8V at pin 3 of U201.

4. If the voltage at pin 3 of U201 is wrong, replace U102.

5. If the voltage is good, connect pin 6 to pin 3 of U201 (U102 pin 6 to pin 7).

6. Measure for approximately +8V at pin 6 of U201.

7. If the voltage at pin 6 of U201 is +8V, replace U102.

8. If the voltage is other than +8V, replace U201.

e. If the voltages on both pins of U203 are approximately +8V, do the following:

1. Measure for approximately +12V at pin 6 of U202.

2. If the voltage is wrong, connect pin 6 to pin 3 of U202.

3. If the voltage is now good, replace U102.

4. If the voltage is still wrong, replace U202.

f. If the Ohms Current Source is still inoperative, replace U203 and then U102.

7-C-22. 4-WIRE [redacted] TROUBLESHOOTING

7-C-23. The only difference between the two ohms functions is that the 4-Wire Ohms Function uses the Ohms SENSE Terminals and a different input path in U102. Make sure the wires from the terminals are connected correctly. Also, make sure the lead resistance of the test used in the 4-Wire Ohms Function is not excessive (<1/30 of full scale reading in the LO INPUT lead and <1/3 of full scale in the HI INPUT lead). If everything appears to be good, U102 may be defective.

SERVICE GROUP D

A/D CONVERTER AND LOGIC TROUBLESHOOTING

SERVICE GROUP D

Title	Paragraph
Introduction	7-D-1
Theory of Operation (Cross Reference)	7-D-3
Pre-Troubleshooting Checks	7-D-8
Rear Panel Switch	7-D-10
Logic Failures and Troubleshooting	7-D-13
Self-Test	7-D-14
Turn-On Failures	7-D-21
Free Running SA (Processor Kernal Test) - SA0	7-D-24
General Signature Analysis - SA1	7-D-26
Troubleshooting the A/D Converter	7-D-33
Check the Reference Voltages	7-D-35
Integrator Test	7-D-38
A/D Converter Circuitry Test - SA2	7-D-40

7-D-1. INTRODUCTION

7-D-2. This Service Group has Logic Circuitry and A/D Converter troubleshooting information for the 3468A. Choose the correct troubleshooting information by referring to the 3468A's failures and failure symptoms, given in this service group.

7-D-3. Most of the procedures in this Service Group require a Signature Analyzer (HP 5004A) for troubleshooting. In addition, two 5" Pomona clips will be useful (HP part-number 8120-1926).

7-D-4. THEORY OF OPERATION (CROSS REFERENCE)

7-D-5. Logic - Paragraph 7-F-50.

7-D-6. A/D Converter - Paragraph 7-F-31.

7-D-7. HP-IL - Paragraph 7-F-62.

7-D-8. PRE-TROUBLESHOOTING CHECKS

7-D-9. Before troubleshooting the 3468A for a Logic or A/D failure, check the following:

a. Check the 5V supply and make sure it is good. The supply should be between +4.9V and +5.1V. If the supply is inoperative, go to Service Group E for troubleshooting.

b. Make sure the $\overline{\text{RESET}}$ line of the Main Controller (U501pin 4) is high. If the line is low, try replacing U550 and then U504.

c. Make sure ALE at JM501 is good as shown in Figure 7-D-1. If the signal is missing or incorrect, make sure the microprocessor's clock, U501(pins 2 and 3) is 6MHz. If the clock signal is missing or wrong, try replacing the crystal Y501. If the signal is still wrong, replace U501.

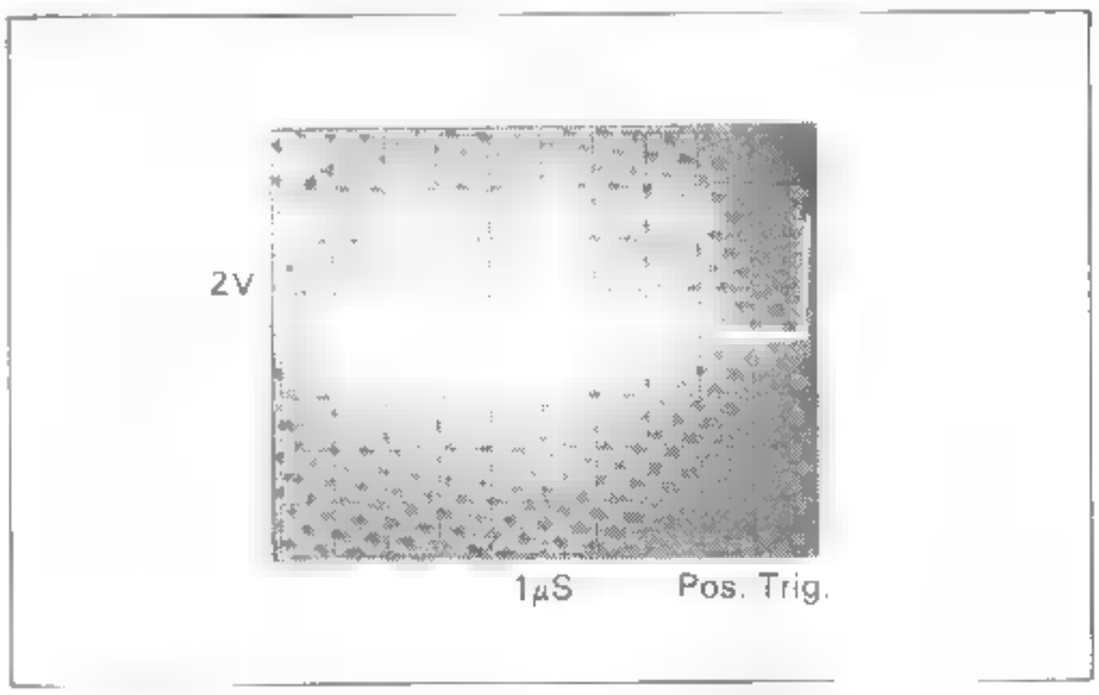


Figure 7-D-1. ALE at JM505

7-D-10. REAR PANEL SWITCH

7-D-11. Before troubleshooting, be sure that S501, the 8 pin dip switch located near the rear panel, has a normal operating configuration. See Table 7-D-1.

7-D-12. On the rear panel of the 3468A there is easy access to four of the eight pins of S501. Access to the other four pins may be gained by taking the top cover off the instrument, and gently lifting the black HP-IL input jack.

Table 7-D-1. S501 Configurations

Switch Number	Switch State: Open ■ ■ (0)	Closed ■ down (1)
1	Talk Only Mode	Normal
2	Not Used	Not Used
3	Power On SRQ	Normal
4	Not Used	Not Used
5	50Hz	60Hz
6	Normal	SA1*
7	Normal	SA2*
8	Normal	Enable Calibration

*SA 1 and SA 2 switches must not be closed at the same time. SA 2 causes the display to go blank.

7-D-13. LOGIC FAILURES AND TROUBLESHOOTING

CAUTION

The 3468A contains CMOS devices which are extremely sensitive to static electricity damage. It is especially important that grounded tools and wrist straps be used when handling or repairing the 3468A. All standard service procedures for preventing static electricity component damage should be followed when handling or troubleshooting these components.

7-D-14. Self-Test

7-D-15. Turn off the instrument, then turn it on again. When the 3468A is powered on, it executes a self-test. First, it displays all segments of its display except the upper dot of the colons. It then checks its ROM, RAM, calibration RAM, and A/D converter. If the 3468A passes these tests, the display will read "SELF-TEST OK" for one second.

7-D-16. If Self-Test is good and you still suspect a digital failure, go to paragraph 7-D-26, General Signature Analysis (SA1).

7-D-17. If there is no meaningful information or the display is blank, go to paragraph 7-D-21, Turn-on Failure.

7-D-18. If one or more failures are detected, "ERROR dd" will appear in the display for about one second. The decimal number, dd, is the arithmetic summation of the individual error message numbers. The error message numbers are:

1 Calibration RAM error
2 RAM error
4 ROM error
8 A/D converter error

If for example, the unit had a defective ROM and was not calibrated, the display would read ERROR 5, which is error 1 (calibration RAM error) + error 4 (ROM error). Notice that any combination of errors will give a unique number.

7-D-19. The one second message can be extended by holding down any key. The message will be held in the display as long as the key is held down. After self-test the 3468A enters its reset state which is DC Volts, Autorange, Autozero on, Internal Trigger, and 5 1/2 Digit Display mode.

7-D-20. The following steps give a description of what each test does and what to do if it fails. When there is more than one error, solve a calibration error LAST.

a. **Calibration RAM Error (1).** This test performs a checksum on the Calibration RAM, so if the test passes, all calibration constants are stored in RAM and the RAM is probably good. It does not however guarantee that the calibration constants will make the 3468A meet its accuracy specifications. If the test fails, try to do a complete calibration, (see Section IV).

1. If during calibration the error message "CAL RAM BAD" is displayed, replace the Calibration RAM (U509).

2. If calibration cannot be enabled (i.e., no "C" appears in the eight character location of the display), first be sure the Calibration Enable switch is in the CAL ENABLE position (switch is down). If the switch is down, make sure the switch is good, then check for a defective U550, U509, and associated circuitry.

3. If the 3468A can be calibrated, set the CAL ENABLE switch up. Then turn the instrument off and on. If the Self-Test still fails, turn the 3468A off and measure battery BT551 and the cathode of CR551. The battery should read approximately 3V dc and the cathode of CR551 should be approximately +2.7V. If BT550 is good but CR551 is not, check C550, CR550, U509, and U550. If the battery voltage is low, something may be loading down the battery. Disconnect the plus side of the battery. If the battery voltage is still low, replace the battery. If it is good, check C550, U550, and CR550. If they are all good, replace U509.

b. **Microprocessor RAM Error (2).** This test performs a checksum on the internal RAM of the microprocessor (U501). If this test passes, the microprocessor is probably good. If this test fails, replace U501. If still inoperative, go to paragraph 7-D-24, SA0, for troubleshooting.

c. **ROM Error (4).** This test performs a checksum on the ROM (U502) so if the test passes, the ROM is probably good. If the test fails, replace the ROM, U502. If this doesn't work go to paragraph 7-D-24, SA0, for troubleshooting.

d. **A/D Converter Error (8).** This test performs a test on the slopes used in Run-up and Run-down. This test (along with another test that occurs every time an A/D conversion is made) assures you that the A/D is working properly. If this test fails, go to paragraph 7-D-33, A/D troubleshooting.

7-D-21. Turn-On Failures

7-D-22. A turn-on failure is when, after power-on, the 3468A has a blank display, partial display, or does not give any self-test information.

7-D-23. First be sure the power supplies and clock are good. Since the display is the most likely cause of a turn-on failure, check the signatures of the lines going into the display. Do the following:

a. Turn the 3468A off.

b. Very carefully disconnect the display cable at the display.

CAUTION

The display assembly, U540 is a CMOS device which is extremely susceptible to static electricity damage. Please use a grounded wrist strap when disconnecting the display cable, W501

c. On S501, put all switches down (closed) except switch 7 and 8, which should be up (open). For 50Hz operation put switch 5 up also.

d. Connect the control leads of the Signature Analyzer as indicated:

Clock	- JM505	- Rising Edge
Start	- JM503	- Falling Edge
Stop	- JM503	- Rising Edge

e. Turn the 3468A on.

f. Check that the +5V signature is F5FH and the ground signature is 0000 before proceeding. If not, recheck connections. If the signatures are still wrong go to paragraph 7-D-24, SA0, for troubleshooting.

g. Read the signatures on the pins of the display cable, W501 (W501 may be shown as P501 on the silkscreen of the A1 board).

Pin	Signature
W501(4)	0000
W501(8)	F5FH
W501(9)	1CC4
W501(10)	2367
W501(11)	2UA8
W501(12)	F119
W501(14)	9FU6
W501(15)	P5CO

h. If any signatures are wrong or unstable go to paragraph 7-D-24, SA0, for troubleshooting.

i. If the signatures are good, check the following voltages on W501 with a Digital Voltmeter.

Pin	# Voltage
W501(1)	3.3V
W501(2)	2.2V
W501(3)	1.1V

j. If the voltages are good, carefully reconnect the display cable and check for 6.6KHz on C501. If good, replace the display. If the display still fails, check the continuity of the display cable.

CAUTION

Use grounded tools and wrist straps when handling the CMOS display. It is extremely susceptible to static electricity damage.

k. If the voltages are on the display are wrong, does W501(pin 3) have 1/3 the voltage of W501(pin 1)? If so, R561 is probably good. The failure is caused by either the power supply or U550. If the voltage of W501(pin 3) is not 1/3 of W501(pin 1), check R561 and U550.

7-D-24. Free Running SA (Processor Kernal Test) - SA0

7-D-25. To establish that basic processor operation is correct, the processor must be isolated from the data bus and the rest of the digital devices, and then examined by itself. Free Running SA (SA0) accomplishes this. For this test you will need a Signature Analyzer and two 5" Pomona clips or their equivalent. Do the following:

a. Turn the 3468A off.

b. Put the switches of S501 in a configuration for normal operation. Refer to table 7-D-1.

c. Use one 5" Pomona clip to connect +5V to R567 (the side of R567 connected to U502, pin 20). Most instruments will have "SA" silkscreened on the proper side of R567.

d. Use another 5" Pomona clip to connect +5V to R502 (the side of R502 connected to U504, pin 2). Most instruments will have "SA" silkscreened on the proper side of R502.

e. Using the Signature Analyzer, connect the control leads as indicated.

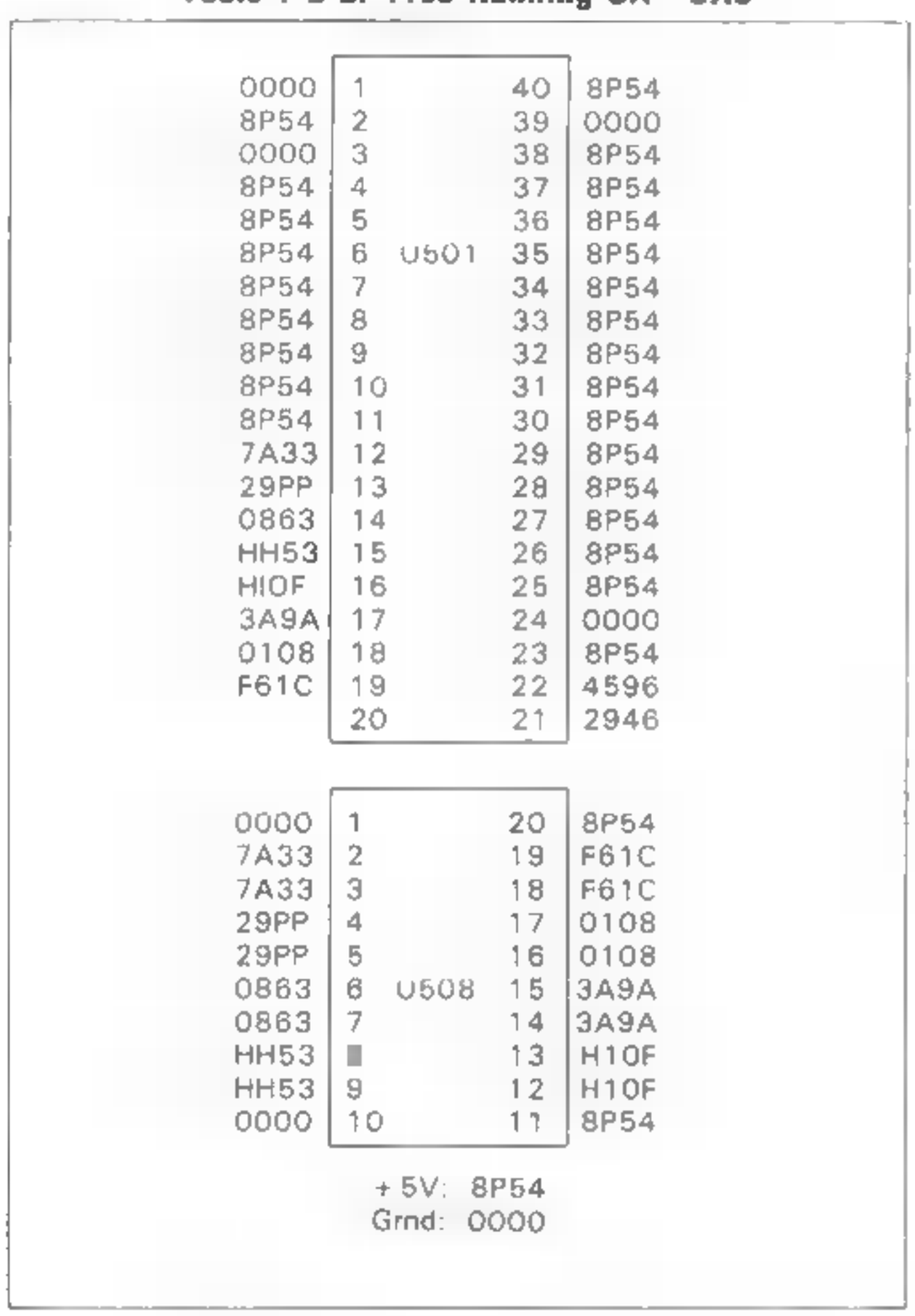
Clock	JM505	- Falling Edge
Start	U501(23)	- Rising Edge
Stop	U501(23)	- Falling Edge

f. Turn the 3468 on.

g. Check that the +5V signature is 8P54 and the ground signature is 0000. If the signatures are wrong recheck your connections first, then check the clock and power supply (see paragraph 7-D-8). If clock and supply are good, replace U501.

h. If the signatures are good, check the signatures on the pins of U501 and U508, as shown in Table 7-D-2.

Table 7-D-2. Free Running SA - SA0



i. If any signatures are wrong or unstable, check the +5V supply and the clocks first, then replace U501 or U508. If replacing the IC doesn't correct the failure, check for opens or shorts on the affected lines. Check also for two lines shorted together.

j. If the microprocessor (U501) signatures and the latch (U508) are good, SA0 is complete and the processor (barring intermittent operation) is good. Proceed to the next paragraph.

7-D-26. General Signature Analysis - SA1

7-D-27. If the microprocessor passes SA0 test according to SA1. SA1 is a general signature analysis which checks the ROM (U502), the registers (U505 and U508), and it verifies that the proper signals are getting to the display and keyboard. SA1 also verifies that the keyboard is operative and that the HP-IL is operating. For SA1 you will need only a signature analyzer. Disconnect the two Pomona clips used in SA0. The sequence described as follows applies to all parts of SA1.

a. Turn the 3468A off.

b. Put all the switches down (closed) on S501, except switch 7 and 8. Put switch 7 and 8 up. For 50Hz operation put switch 5 up also.

c. Turn the 3468A on.

d. All segments of the display should be lit, except the top dot of the colon. If not, check S501. If still inoperative, troubleshoot the display (paragraph 7-D-29).

7-D-28. ROM Test. Test the ROM, U502 as follows:

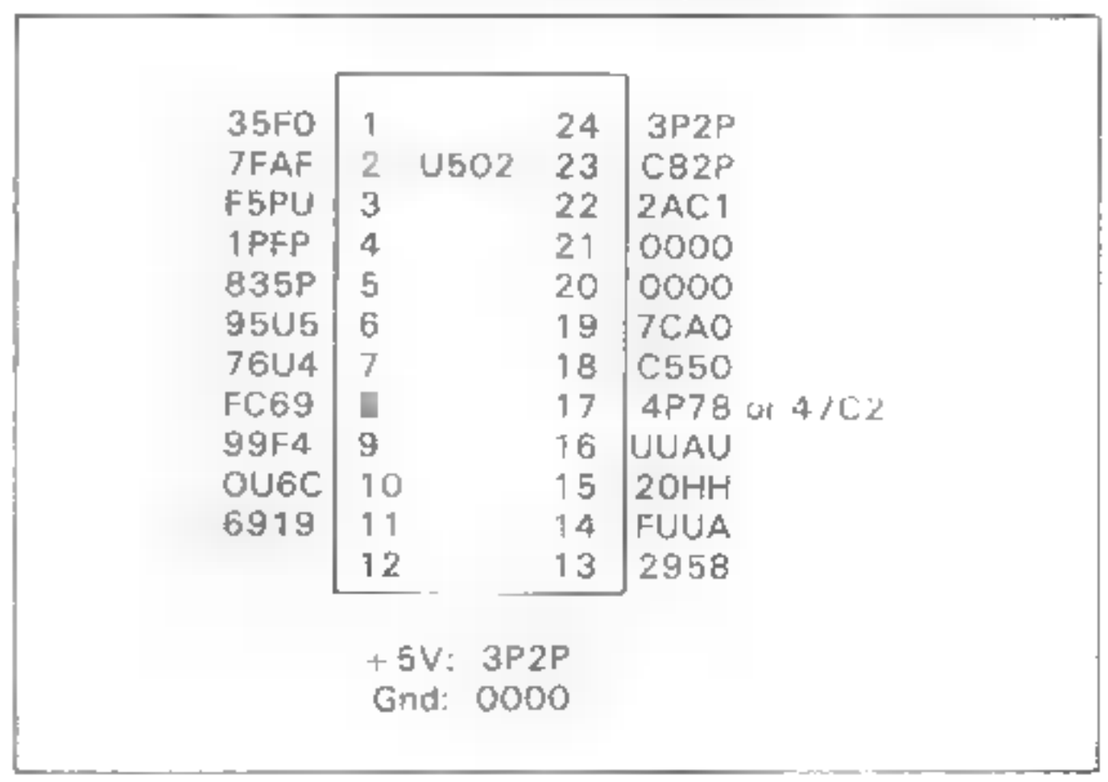
a. Connect the signature analyzer control leads as indicated.

Clock	R567*	Rising Edge
Start	JM503	Falling Edge
Stop	JM503	Rising Edge

*Connect the control leads to the side of R567 attached to U502 (pin 20). Most instruments will have "SA" silkscreened on the proper side of R567.

b. Check the signatures that are listed in table 7-D-3.

Table 7-D-3. ROM Signatures



c. If any of the signatures are wrong or unstable, replace the ROM (U502). If replacing the ROM doesn't correct the failure, the failure is most likely on the data bus. Check each line for a stuck 1 (3P2P) or 0 (0000), or two lines shorted together.

d. If the signatures are good, the ROM is probably good, continue with the next paragraph.

7-D-29. Display, Register (U505,U507),and Keyboard Test. This part of SA1 tests the registers (U505,U507), and it verifies that the display, DAC (R401-R406), and keyboard are getting the proper information. To do this test, the instrument must pass SA0 and the ROM test first.

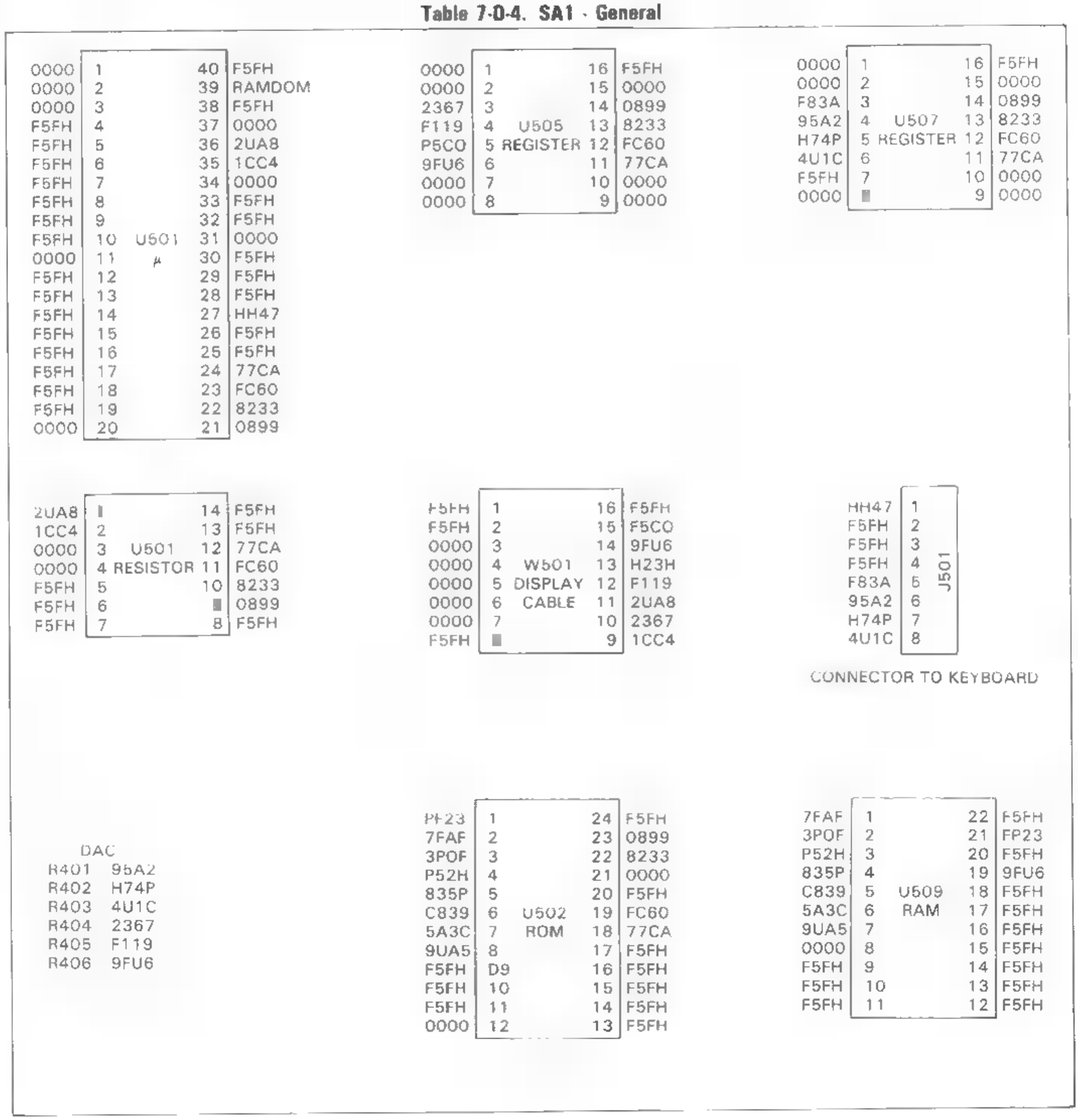
a. Connect the Signature Analyzer leads as indicated.

Clock	JM505 - Rising Edge
Start	JM503 - Falling Edge
Stop	JM503 - Rising Edge

b. Check the + 5V signature (F5FH), and the ground signature (0000). If the signatures are wrong, be sure that your connections are correct and be sure that the instrument has passed SA0 and the ROM test. Then check for a stuck 1 or 0.

c. Check the signatures as shown in Table 7-D-4.

Table 7-D-4. SA1 - General



d. If any of the signatures of W501 are wrong or unstable, check the signatures of U505 (pins 11,12,13,14). If these signatures of U505 are good, replace U505. If that doesn't solve the problem, check the continuity of the cable. If the signatures of U505 are wrong, be sure that the instrument has passed SA0, otherwise check for stuck bus lines.

e. If the signatures of W501 are good, the information going to the display is good. Now check the signatures of J501.

f. If any of the signatures of J501 are wrong or unstable, check the signatures of U507 (pins 11,12,13,14). If the signatures of U507 are good, replace U507. If the signatures of U507 are wrong, be sure that the instrument has passed SA0, otherwise check for stuck bus lines.

g. If the signatures of J501 are good, the information going to the keyboard is good. If you still suspect a keyboard failure, go to the Keyboard Test, paragraph 7-D-30 for troubleshooting.

h. If the signatures coming from the microprocessor (U501) are good, but the ROM has some wrong signatures, replace the ROM (U502). If the Rom passes SA1 it is added confidence that the ROM is working correctly.

i. If signatures are wrong on any of the other components shown in Table 7-D-4, look for a stuck 1 or 0. The microprocessor (U501), Rom (U502), and registers (U508 and U509) are the only active components during this test.

7-D-30. Inoperative Keyboard Test. An inoperative keyboard is when all or part of 3468A operations cannot be selected from the Keyboard. This can be caused by the keyboard itself or the microprocessor. Be sure to go through SA0 and the previous SA1 test that checked the information going to the keyboard. Do the following:

a. Be sure S501 is set up as in paragraph 7-D-27 step b.

b. Connect the control leads of the signature analyzer as follows:

Clock	JM505	- Rising Edge
Start	JM503	- Falling Edge
Stop	JM503	- Rising Edge

c. By pressing a certain front panel button, the signature on a port of U501 should change. For example, the signature on U501 pin 27 should change from "HH47" to "8H28", if the ⎓V button is pressed. From this change, it can be determined if the button (i.e., part of the keyboard) is inoperative or good. The following lists the pin numbers of U501, the button to be pressed, and the change in signature.

U501 pin#	Press Button	Change Signature From	To
27	~V	HH47	8H28
27	AUTO/MAN	HH47	FUFA
27	⎓A	HH47	H0C0
27	SGL/TRIG	HH47	4U1C
28	~V	F5FH	95A2
28	UP RANGE	F5FH	H74P
28	~A	F5FH	F83A
28	SRQ	F5FH	4U1C
29	2 WIRE	F5FH	95A2
29	DOWN RANGE	F5FH	H74P
29	SHIFT	F5FH	F83A
29	LOCAL	F5FH	4U1C
30	4 WIRE	F5FH	95A2
30	INT/TRIG	F5FH	H747

7-D-31. HP-IL Failure. Before troubleshooting for an inoperative HP-IL, make sure the 3468A is operating correctly from the front panel. Repair the front panel operation first, before troubleshooting for an HP-IL failure.

7-D-32. To troubleshoot the HP-IL, you will need a Signature Analyzer and an HP-IL Cable. Then do the following:

a. Make sure S501 is set up as given in paragraph 7-D-27 step b.

b. Connect the control leads of the signature analyzer as follows:

Clock	JM505	- Rising Edge
Start	JM501	- Falling Edge
Stop	JM501	- Rising Edge

c. Connect the HP-IL Cable from the 3468A's HP-IL Input Jack to the 3468A's HP-IL Output Jack.

d. Check the +5V signature (U085).

e. If the signature is good, HP-IL is operating correctly. Make sure the instrument front panel operation is good. If the signature is wrong, make sure the HP-IL Cable is making good contact. If it is, check the continuity of the HP-IL Input Connector and Output Connector (on the 3468A's rear panel). To check continuity, connect an ohmmeter from one outer pin to the other outer pin of the Output Connector. Do the same for the Input Connector. This checks part of the HP-IL Connectors, and T501 and T502. If there is no continuity, check for poor solder joints on the connectors, and if the joints are good, replace T501 or T502. If there is continuity, replace U503.

7-D-33. TROUBLESHOOTING THE A/D CONVERTER

7-D-34. Either of two front panel error messages would indicate an A/D (Analog to Digital) converter failure. The first of the two messages is ERROR 8, which means that the failure was discovered during the 3468A Self-Test. The second message is A-D ERROR, which indicates the failure was discovered while the 3468A was attempting to take a reading. The following paragraphs will assist you in localizing faults in the A/D converter circuitry.

7-D-35. Check the Reference Voltages

7-D-36. As explained in the theory of operation (Service Group F), the +10V reference and the -10V reference supplies are essential for proper A/D conversion. The +10V reference should be checked at pin 6 of U402, and pins 20 and 24 of U403. The -10 volt reference should be checked at pin 6 of U405, pin 6 of U404, and pins 13, 15, 18, and 23 of U403. The reference supplies should be within ±3% of 10 volts and within .02% of each other.

a. If the -10V reference is good but the +10V reference is incorrect, lift JM201. If the +10V reference is now good, the problem lies in the Ohms Converter. If the +10V is still incorrect, either U402 or U403 is defective.

b. If the -10V reference is incorrect, measure the voltage at the anode of CR401. If the voltage is not approximately -6.9 volts, either CR401 or R439 is defective.

c. If the voltage at the anode of CR401 is correct, use a clip lead to short across C431. Measure the voltage at pin 6 of U405. It should be approximately the same as the voltage on the anode of CR401. If it is not, replace U405, otherwise replace U403. Remove the clip lead.

d. If the -10V reference is correct at pin 6 of U405 but not at pin 6 of U404, replace U404.

7-D-37. If the reference voltages are correct, it will be necessary to troubleshoot the A/D converter circuitry. This is comprised of an integrator, U401; A/D converter, U403; and DAC (Digital to Analog Converter) resistors R401 to R405. Two procedures are described for troubleshooting this circuitry. The first, beginning with paragraph 7-D-38, checks only integrator U401. If it checks good, U403 is most likely defective. The second method, beginning with paragraph 7-D-40, tests the integrator; U403 DC input, comparator, and run-up/run-down; as well as the DAC resistors (R401-R405).

7-D-38. Integrator Test

7-D-39. The following procedures provide a simple method of troubleshooting U401, the integrator.

a. Connect one 10K ohm resistor across (in parallel with) C410.

b. Disconnect JM405. Connect a 10K ohm resistor from pin 2 of U401 to the +10V reference.

c. Measure the voltage at pin 6 of U401. It should be approximately -10V.

d. Now connect the second 10K ohm resistor to the -10V reference. The voltage at pin 6 of U401 should be +10V.

e. If either measurement (step c or d) is incorrect, replace U401.

f. Remove both 10K ohm resistors and replace JM405.

7-D-40. A/D Converter Circuitry Test - SA2

7-D-41. The following procedures may be used to troubleshoot the complete A/D converter circuitry. Although a storage oscilloscope, such as the -hp- Model 1741A would be beneficial, it is not necessary.

a. Remove JM 101. Connect pin 6 of U401 to pin 25 or 26 of U403.

b. Set switch 7 (rear panel bank of switches) to the down position.

c. Set up the oscilloscope as follows:

Channel A. Connect to pin 6 of U401.
Vert V/DIV.: 1V/DIV.
Channel B. Connect to pin 11 of U403.
Vert V/DIV.: .5V/DIV
Horizontal. 50mS/DIV.
Use 10:1 oscilloscope probes

d. Adjust triggering (trigger on channel A) for the display shown in Figure 7-D-2. The top display indicates the output of the integrator. The bottom display is the output of the comparator. If the top display is correct but the bottom is not, replace U403.

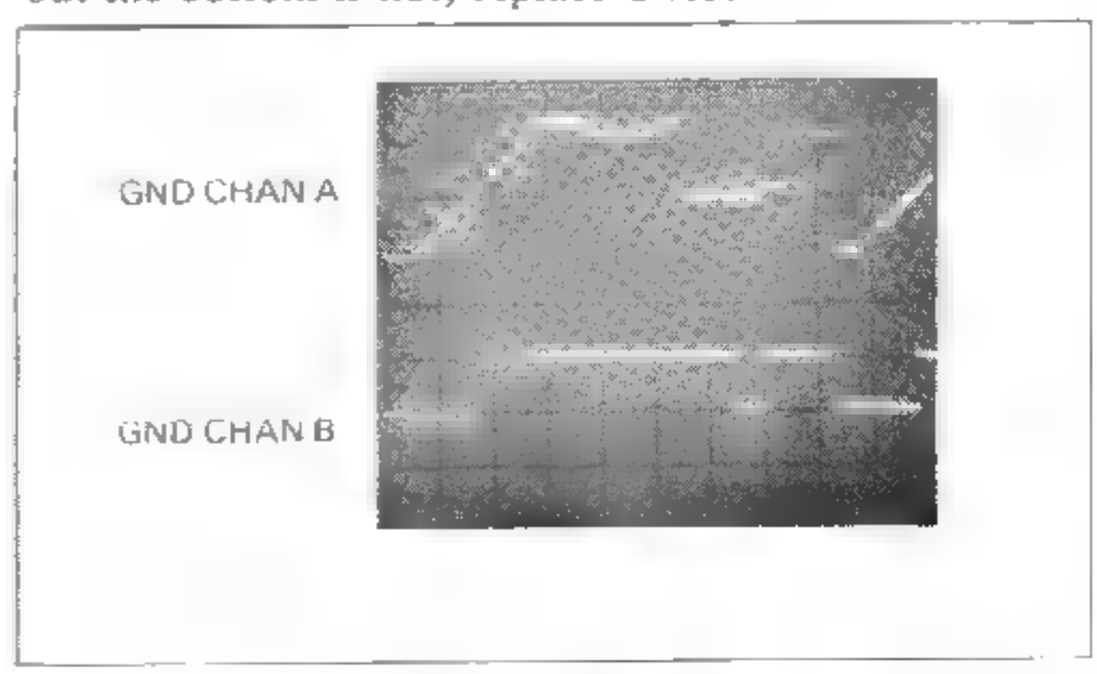


Figure 7-D-2. A/D Converter Test With Comparator

e. Adjust Channel A Vert. V/DIV to .5V/DIV. Turn off Channel B. This should provide the waveform shown in Figure 7-D-3. Any discrepancy in the left portion of the display indicates a failure in the DAC. Check resistors R401 through R405. Discrepancies in the right portion of the display indicates a failure in the run-up/run-down portion of the A/D Converter. Replace U403.

7-D-42. It is possible for the microprocessor, U501, to cause an A/D failure. This would be caused by a failure of the controller to communicate with the A/D Converter U403.

Figure 7-D-3. A/D Converter Test

SERVICE GROUP E

MISCELLANEOUS TROUBLESHOOTING

Service Group E Contents

Title	Paragraph
Introduction	7-E-1
Power Supply Troubleshooting	7-E-3
Reference Circuitry Troubleshooting	7-E-10
Battery Charger Circuitry Troubleshooting	7-E-12
Battery Charger Troubleshooting	7-E-14
DC to DC Converter Troubleshooting	7-E-16

7-E-1. INTRODUCTION

7-E-2. This Service Group has information on how to troubleshoot the 3468A's Power Supplies, Reference Circuitry, and the optional Battery Charger Circuitry.

7-E-3. POWER SUPPLY TROUBLESHOOTING

7-E-4. The 3468A has three power supplies: +5V, -15V, and +15V. The following paragraphs have some troubleshooting information for the Chassis Common and Floating Common supplies (refer to Schematic 4).

7-E-5. +5V Supply. A low supply can be caused by an excess load on the supply, a shorted CR712 or C705, or a defective U701. The supply can be checked by lifting jumper +5. If the supply is still low, troubleshoot the supply.

7-E-6. A high supply is most likely caused by a defective U701.

7-E-7. +15V and -15V Supplies. Since the -15V supply is a mirror image of the +15V supply, use the following procedure for both supplies. (The only difference is that the -15V supply has an additional filter capacitor C706.)

7-E-8. A low supply can be caused by an excessive load on the supply, a shorted filter capacitor or protection diode, an open temperature sensitive resistor (RT705), or a defective regulator. The supply can be checked by lifting jumper +15 for the +15V supply or jumper -15 for the -15V supply. If still low, troubleshoot the supply.

7-E-9. A high supply is most likely caused by the regulators (U702 or U703).

7-E-10. REFERENCE CIRCUITRY TROUBLESHOOTING

7-E-11. The 3468A's Reference Circuitry is used to develop three reference voltages: +10V, -10V, and a buffered +10V. Since the -10V and buffered +10V depends on the +10V reference voltage, make sure the +10V is good before troubleshooting the other reference supplies. Perform the following checks (refer to Schematic 3).

a. If the +10V reference is inoperative, do the following:

1. Measure the voltage at zener diode CR401. The voltage should be quiet and at approximately +6.9V.

2. If the voltage is wrong, make sure R439 is good. If the resistor is good, replace CR401.

3. If the voltage is good, short across capacitor C431. Measure pin 6 of U405.

4. If the voltage at pin 6 is approximately +7V and quiet, replace U403.

5. If the voltage is still incorrect or noisy, replace U405.

b. If the +10V is good and the -10V is incorrect or noisy, replace U404. If still incorrect or noisy, replace U403.

c. If both +10V and -10V voltages are good and the buffered +10V is low, lift jumper JM201 (see Schematic 1). If the +10V is now good, replace U102. If still wrong, continue with the next step.

d. If the buffered +10V is wrong or noisy, do the following:

1. Check for a quiet -10V at pin 2 of U402.

2. If the voltage is wrong, replace U403.

3. If the voltage is good, connect pin 19 to pin 24 of U403.

4. If the voltage at pin 6 of U402 is now at +10V, replace U403. If not, replace U402.

7-E-12. BATTERY CHARGER CIRCUITRY TROUBLESHOOTING

7-E-13. The purpose of the Battery Charger Circuitry is to allow the 3468A to operate on an internal battery (BT901). The circuitry is used to charge the battery when the 3468A is connected to the ac power source and to generate the raw (unregulated) voltages for the 3468A's internal power supply. If the 3468A does not operate with its ac power source disconnected, check the following (refer to Schematic 5):

a. With the 3468A unplugged from its ac power source, turn the 3468A on.

b. Connect the high input of a DC Voltmeter to the positive terminal of battery BT901 and connect the low input of the voltmeter to the negative terminal of the battery. Measure for +6V dc.

c. If the voltage is at or above +6V, check for an open fuse F901 or the printed circuit board fuse (see note on Schematic 5). The printed circuit board fuse is a thin trace near J901 (J901 is a red wire going to the positive terminal of the battery). If the fuse is open, it can be replaced by a 28 gauge single strand wire. Insert and solder the wire into the holes on each end of the trace.

d. If the fuses are good and the battery is above +6V dc, troubleshoot the DC to DC Converter and associated control circuitry. Go to paragraph 7-E-16 for troubleshooting.

e. If the voltage is below 6V dc, the Battery Charger Circuitry may not be charging the battery or the battery itself is defective. Go to paragraph 7-E-14 for troubleshooting.

7-E-14. Battery Charger Troubleshooting

7-E-15. The battery is charged with a current of approximately 400mA, when the 3468A is connected to its ac power source and turned off. Do the following to check the circuitry.

a. Turn the 3468A off and unplug the instrument from its ac power source.

b. Check and make sure the Battery Charger Circuitry develops the correct current for the battery. Two methods can be used to check the current. One method uses an ammeter (like the 3468A or 3478A) to check the current and is given in step c. The other method uses a DC Digital Voltmeter (like the 3456A) and a 10 ohm 5 watt resistor. This method is in step d.

c. To check the charge current using an ammeter, do the following:

1. Disconnect the red battery lead from the battery and connect it to the A (Amps) input of the ammeter.

2. Connect the LO input of the ammeter to the black battery lead (ground).

3. Make sure the 3468A is turned off, then plug the instrument into its ac power source.

4. The current should be approximately 400mA dc.

5. If the current is wrong, the battery charger is defective. Go to step e for further troubleshooting.

6. If the current is good, turn the 3468A on. The current should change to approximately 140mA dc. If the current does not change, replace U902. If it does change, the battery is most likely defective. Replace the battery.

d. To check the charge current using a Digital Voltmeter and a 10 ohm resistor, do the following:

1. Disconnect the red battery lead from the battery and connect it to one side of the 10 ohm resistor.

2. Connect the other side of the resistor to the black battery lead (ground).

3. Make sure the 3468A is turned off, then plug the instrument into its ac power source.

4. Using the Digital Voltmeter, measure the voltage across the 10 ohm resistor. It should be approximately 4V dc.

5. If the voltage is wrong, the battery charger is defective. Go to step e for further troubleshooting.

6. If the voltage is good, turn the 3468A on. The voltage should approximately 1.5V dc. If the voltage does not change, replace U902. If it does change, the battery is most likely defective. Replace the battery.

e. Measure for +2.5V at pin 2 of U901 (use the black battery lead as ground).

f. If the voltage at pin 2 of U901 is good, check for an open R908, R910, and R740 (see Schematic 4). If the resistors are good, check for an open CR906, and an open or shorted Q901 or Q906. If Q901, Q902, and CR906 are good, replace U902.

g. If the voltage at pin 2 is low or missing, make sure pin 1 of U901 is at least +10V. If the voltage is missing, check for an open CR901, CR902, or CR904.

h. If the voltage at pin 1 of U901 is good, replace U901. If the voltage at pin 2 of U901 is still wrong (other than +2.5V), replace U902.

7-E-16. DC to [redacted] Converter Troubleshooting

7-E-17. The DC to DC Converter develops the raw (unregulated) voltages for the 3468A's power supplies, when the instrument is unplugged. The circuitry consists of two major areas, the sense circuit and the converter itself. The part of the sense circuit is used to turn the DC to DC Converter on, when the 3468A is unplugged from its ac power source. The other part of the sense circuit is used to turn the converter off, if the battery voltage is too low.

7-E-18. Before troubleshooting the DC to DC Converter, make sure bridge rectifiers CR906 through CR909, and CR912 through CR914 are good. Also make sure C907 through C909 are not shorted. If they are good, do the following:

a. Turn the 3468A off and unplug the instrument from its power source.

b. Unsolder and lift the end of jumper JM901 which is connected to U903 pin 4 (toward the rear of the 3468A).

c. Turn the 3468A on.

d. Connect the lifted end of jumper JM901 to the positive terminal of the battery.

e. If the 3468A operates with JM901 connected to the battery, the sense circuitry is inoperative. With JM901 connected to the battery, do the following:

1. Make sure pin 2 of U903 is low. If the pin is high, check for a shorted C904. If C904 is good, replace U902. (A low is at approximately zero volts and a high is the battery voltage, approximately +6V.)

2. If pin 2 of U903 is low, check for a high level at pin 1 of U903.

3. If the level at pin 1 of U903 is high, replace U903.

4. If the level at pin 1 of U903 is low, make sure pin 4 of U902 is at approximately 2.5V. If the voltage is good, make sure pin 5 is larger than the voltage at pin 4 (above +2.5V). If it is above +2.5V, replace U902. If not, make sure R911, R912, and the battery are good.

f. If the 3468A is still inoperative, the DC to DC Converter itself is defective. With JM901 connected to the battery, do the following:

1. Using an oscilloscope, make sure the signal at jumper JM902 of U905 is a 28KHz square wave, as shown in Figure 7-E-1.

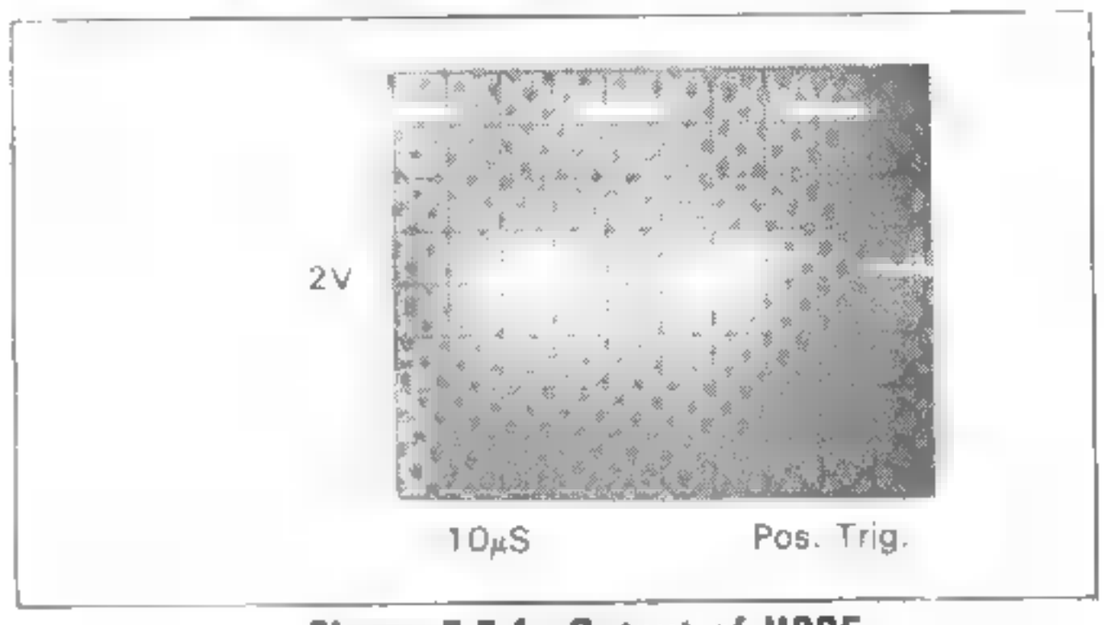


Figure 7-E-1. Output of U905

2. If the square wave is missing or wrong, make sure R913, R916, C911, and CR911 are good. If they are good, replace U905.

3. If the signal at JM902 is good, check for the signal shown in Figure 7-E-1 at U904 pin 11.

4. If the signal at pin 11 of U904 is missing or wrong, replace U904.

5. If the signal at pin 11 of U904 is good, check for the signal shown in Figure 7-D-2 at the collector of Q904 (pin 2 of transformer T901).

6. If the signal is wrong, make sure Q903, Q904, and Q905 are good. If they are good, check for a defective transformer T901.

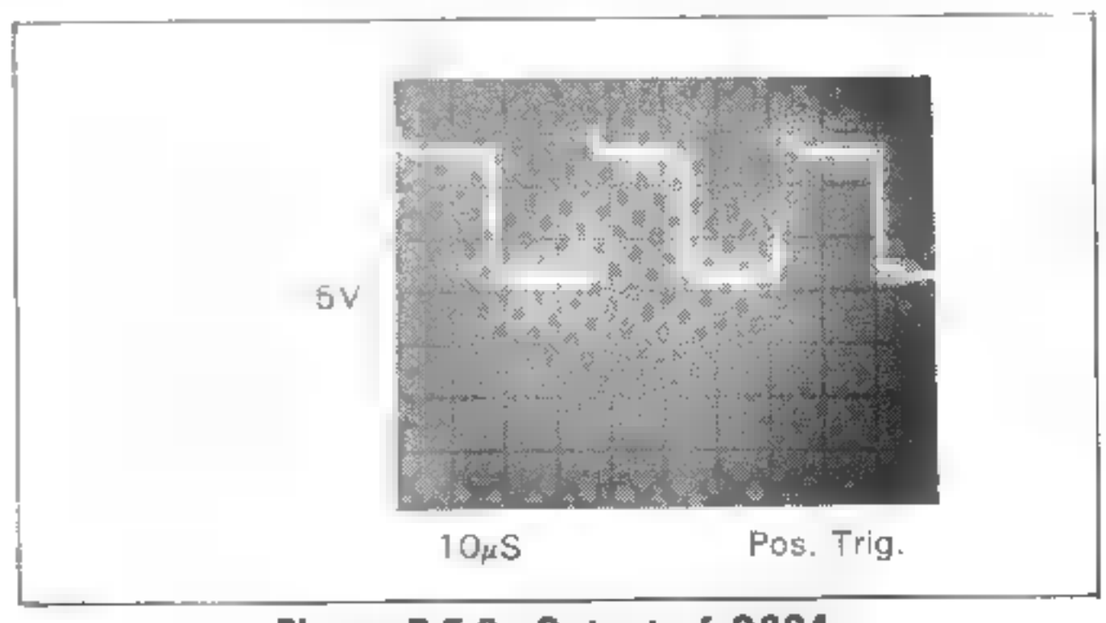


Figure 7-E-2. Output of Q904

SERVICE GROUP F
THEORY OF OPERATION

Service Group F Contents

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3468A Control Logic Circuitry	7-F-50
Power Supplies	7-F-67
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7-F-1. INTRODUCTION

7-F-2. The following Service Group has the general and detailed description of the operating circuitry of the -hp- Model 3468A Multimeter. The general description explains the purpose of each operating block of the 3468A Simplified Block Diagram (shown in Figure 7-F-1). The detailed description explains the circuitry in each operating block.

7-F-3. GENERAL BLOCK DIAGRAM THEORY OF OPERATION

7-F-4. Refer to Figure 7-F-1 for the following discussion of the 3468A's General Block Diagram Theory Of Operation.

7-F-5. The 3468A can be separated into two major areas, Measurement Circuitry and Control Circuitry.

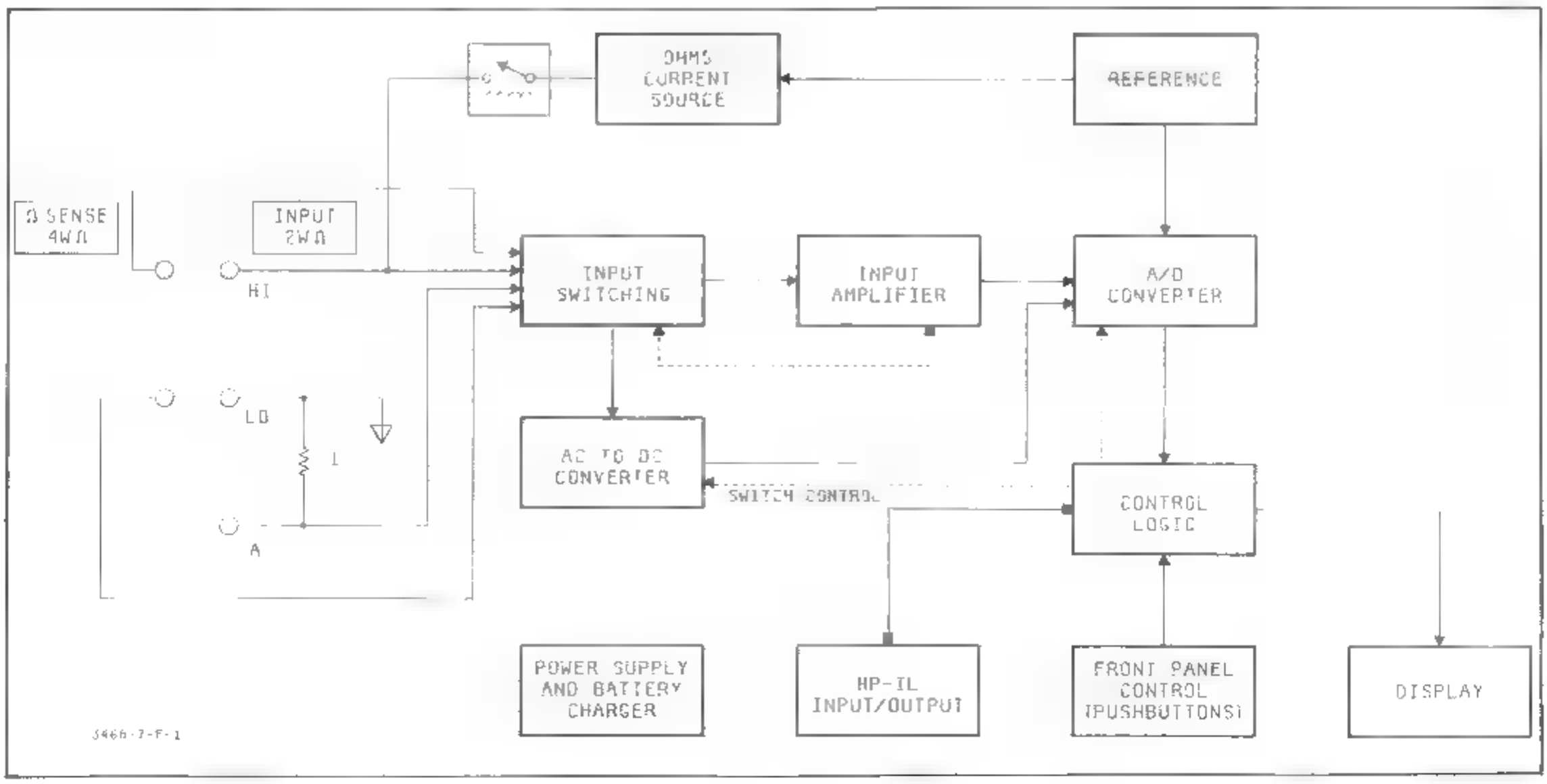


Figure 7-F-1. [redacted] Simplified [redacted] Diagram

The Measurement Circuitry consists of the Input Circuitry, A/D Converter, Ohms Current Source, and AC to DC Converter. The Control Circuitry is used to calculate and display readings, sets up the measurement circuitry (Input Circuitry, etc.) for a particular function and range, and sends and receives remote information. It consists of the Main Controller (main CPU) and associated circuitry.

7-F-6. The following paragraphs explain a typical measurement sequence.

a. **Set-up.** The 3468A receives range and function information from the front panel (local) or over the HP-IL (remote). The information is received by the Main Controller which then sets up the Measurement Circuitry to do the desired measurement. The Main Controller also sends information to the display to show the selected function and range.

b. **DC Volts Function.** The following occurs if the DC Volts Function is selected.

1. The Input Circuitry is set up to a certain gain configuration by the Main Controller. The gain depends on the range selected.

2. The input voltage is amplified or attenuated (dependent on the range) to 10V (for full scale inputs) which is then applied to the A/D Converter.

3. The A/D Converter changes the voltage to digital information and transfers it to the Main Controller.

4. The Main Controller takes the information and calculates the correct reading. The correct reading is calculated by using the zero measurement (see step f) and the calibration constant(s) (which are stored in the Calibration RAM).

5. The corrected reading is then sent to the front panel to be displayed and sent over the HP-IL (if the 3468A is in remote and addressed to talk).

c. **Ohms Function.** If the Ohms Function is selected, the Ohms Current Source supplies a dc current to the unknown resistance. A voltage drop proportional to the unknown resistance and the current is applied to the Input Terminals. A regular dc measurement is then made (see step b) and the ohms reading is calculated by the Main Controller circuitry using the zero measurement (see step f) and calibration constant(s).

d. **AC Volts Function.** If the AC Volts Function is selected, the input is connected to the AC to DC Converter. The converter changes the voltage to its equivalent (RMS) dc voltage and applies it to the A/D Converter. The A/D Converter changes the voltage to digital information and sends it to the Main Controller. The controller then calculates the correct reading using the zero measurement calibration constant(s).

e. **AC Current or DC Current Function.** If the AC Current or DC Current Functions are selected, the input current is applied to resistor A1R107 (.1 ohm). The resultant voltage drop across the resistor is then measured. An ac or dc volts measurement is made, dependent on the function selected (AC Current or DC Current, respectively).

f. **Autozero Function.** If the 3468A's Autozero Function is enabled, an offset measurement (known as a zero measurement) is made before an input measurement. The zero measurement is made by connecting the input of the Input Amplifier (HI INPUT Terminal is open) to ground (LO INPUT Terminal). The resultant offset of the amplifier is then measured and stored into memory. This reading is then subtracted from the DC Volts, DC Current, and Ohms readings that follow. If the AC Volts or AC Current Functions are selected, the zero reading is taken differently. The input to the A/D Converter is shorted to ground instead of the DC/Ohms Input Amplifier.

7-F-7. THEORY OF OPERATION

7-F-8. General

7-F-9. The following paragraphs give a detailed description of the operating circuitry in the 3468A. The circuitry is explained in the following order:

a. Input Circuitry - paragraph 7-F-10.
b. Ohms Current Source - paragraph 7-F-17.
c. AC to DC Converter - paragraph 7-F-25.
d. A/D Converter - paragraph 7-F-30.
e. Logic Circuitry - paragraph 7-F-50.
f. Power Supplies - paragraph 7-F-67.
g. Battery Charger - paragraph 7-F-72.

7-F-10. Input Circuitry

7-F-11. General. The purpose of the Input Circuitry is to condition the dc input signals to the 3468A to provide full scale 10V dc input voltages to the A/D Converter, for full scale inputs to the 3468A (the explanation for ac inputs is in paragraph 7-F-25, AC to DC Converter). The Input Circuitry also acts as a buffer between the input and the A/D Converter. The circuitry can be separated (and is explained) as follows:

Overvoltage Protection
Input Switching
Autozero and Pre-Charge
Pre-Charge Stage
DC/Ohms Input Amplifier

7-F-12. Overvoltage Protection. This circuitry has three parts: High Voltage Protection, Low Voltage Protection, and Current Protection. The two circuits

operate ■ follows (refer to Schematic 1 for the explanation):

a. **High Voltage Protection.** This circuit consists of a 630V Surge Voltage Protector (E101) in series with two 51K ohm resistors. The circuitry is connected between the HI and LO INPUT Terminals and conducts with ■ peak voltage level of 630V (±20%), which provides ■ low impedance path across the terminals. Capacitor C104 provides a temporary low impedance path, and R108 and R109 provides current limiting, if E101 continuously conducts.

b. **Low Voltage Protection.** This circuit consists of diodes connected to the individual input nodes (part of the HI Input, LO Input, A Input Paths, etc.). The diodes on each node are connected (internally in U102) to +3.5V and -3.5V power supplies. If the voltage on ■ node exceeds either +4.2V or -4.2V, a diode conducts and keeps the level on the node to the ±4.2V levels. The difference between the high voltage at the input terminals and the voltage at the input nodes is dropped across the resistors which are in series with the diodes and input terminals (the low pass filter). Figure 7-F-2A shows ■ typical protection circuit.

c. **Current Protection.** A fuse in series with the current shunt (R107) protects the shunt from excessive input currents (>3A) and voltage sources. Open circuit voltage of current sources should not exceed the 250V rating of the fuse.

7-F-13. Input Switching. The Input Switching Circuitry consists mostly of Relay and MOSFET switches, with most FET switches located in U102. The purpose of the switches is to provide five signal paths to the Input Amplifier and to connect the amplifier for a zero measurement (done in the Autozero Function; see paragraph 7-F-14). The switches ■ controlled by circuits in U102 which receive their control information from the A/D Controller. The following explains the various input paths. Refer to Figure 7-F-2 and Schematic 1 for the explanation.

a. **Low Voltage Range Input Path (Figure 7-F-2B).** The path consists of K101, R103, R104, R110, and S1DC (S1DC is in U102). The purpose of the path is to connect the HI INPUT Terminal (high input voltage) to the DC/Ohms Input Amplifier. The path is used only in the .3V through 3V dc volts Ranges and all Ohms Ranges.

b. **High Voltage Range Input Path (Figure 7-F-2C).** The path consists of R110, K102, S2DC (in 102), and ■ 100:1 divider (9.9M ohm and 100K ohm resistors, RD99 and RD98, in U102). The purpose of the path is to attenuate input voltages by a factor of 100 and to connect the attenuated voltage to the DC/Ohms Input Amplifier. The path is used only in the 30V and 300V dc volts Ranges.

c. **Ohms High Sense Path (Figure 7-F-2D).** This path consists of R105, R106, and S4ADC and S4BDC (S4ADC and S4BDC are in U102). The path connects the HI OHMS SENSE Terminal (high ohms input) to the DC/Ohms Input Amplifier, only when the 3468A is in the 4-Wire Ohms Function. Switch S4CDC (which is also part of the path) is used to connect the junction of S4ADC and S4BDC to ground. Switch S4CDC is closed in all functions except the 4-Wire Ohms Function and shunts any possible voltage on the S4ADC and S4BDC junction to ground.

d. **Ohms Low Sense Path (Figure 7-F-2E).** This path consists of R101, R102, S6ADC, and S6CDC (S6ADC and S6CDC are in U102). The path is used to connect the LO OHMS SENSE Input Terminal (low ohms input) to ground (LO INPUT Terminal), when the 3468A is in the 4-Wire Ohms Function. In the 2-Wire Ohms Function, the low ohms input is the LO INPUT Terminal (which is connected to ground).

e. **Current Input Path (Figure 7-F-2F).** This path includes R107 and S3DC (in U102). The voltage drop across R107 (which is generated by the current being measured) is connected through S3DC to the DC/Ohms Input Amplifer. This path is used only in the DC Current Function.

7-F-14. Autozero. The Autozero Function of the 3468A is used to measure the offset of the DC/Ohms Input Amplifier and subtract it from the input measurement. As long as the Autozero Function is enabled, an offset measurement is taken between each input measurement. The offset measurement is called "measure zero" and is done in two different ways, dependent on the function selected. The following explains the two ways to make the measurement and the circuitry used.

a. **Autozero (in DC Volts, DC Current, and 2-Wire Ohms Functions).** In the DCV, DCI, and 2-Wire Ohms Functions, the offset measurement (measure zero) is made with switch MC (measure customer) open, and switch MZ (measure zero) and S8DC closed (see Figure 7-F-2G). Switch S8DC and MZ connects the DC/Ohms Input Amplifier to ground through a 102K ohm resistor. After the offset measurement is made, switch S8DC and MZ opens, and switch MC closes for the input measurement. (Note: MOSFET switches MC, MZ, and S8DC are in U102.)

b. **Autozero (in the 4-Wire Ohms Function).** In the 4-Wire Ohms Function, the offset measurement is made with switch MC (and S8DC) open and switch MZ, S6ADC, and S6BDC closed. The DC/Ohms Input Amplifier is connected to ground through the Ohms Low Sense Path (includes ■ externally connected lead; see Figure 7-F-2H) to the LO INPUT Terminal. This measurement is different than in the DC Volts, DC Current, and 2-Wire Ohms Functions, since the Input Amplifier is connected to ground through the externally

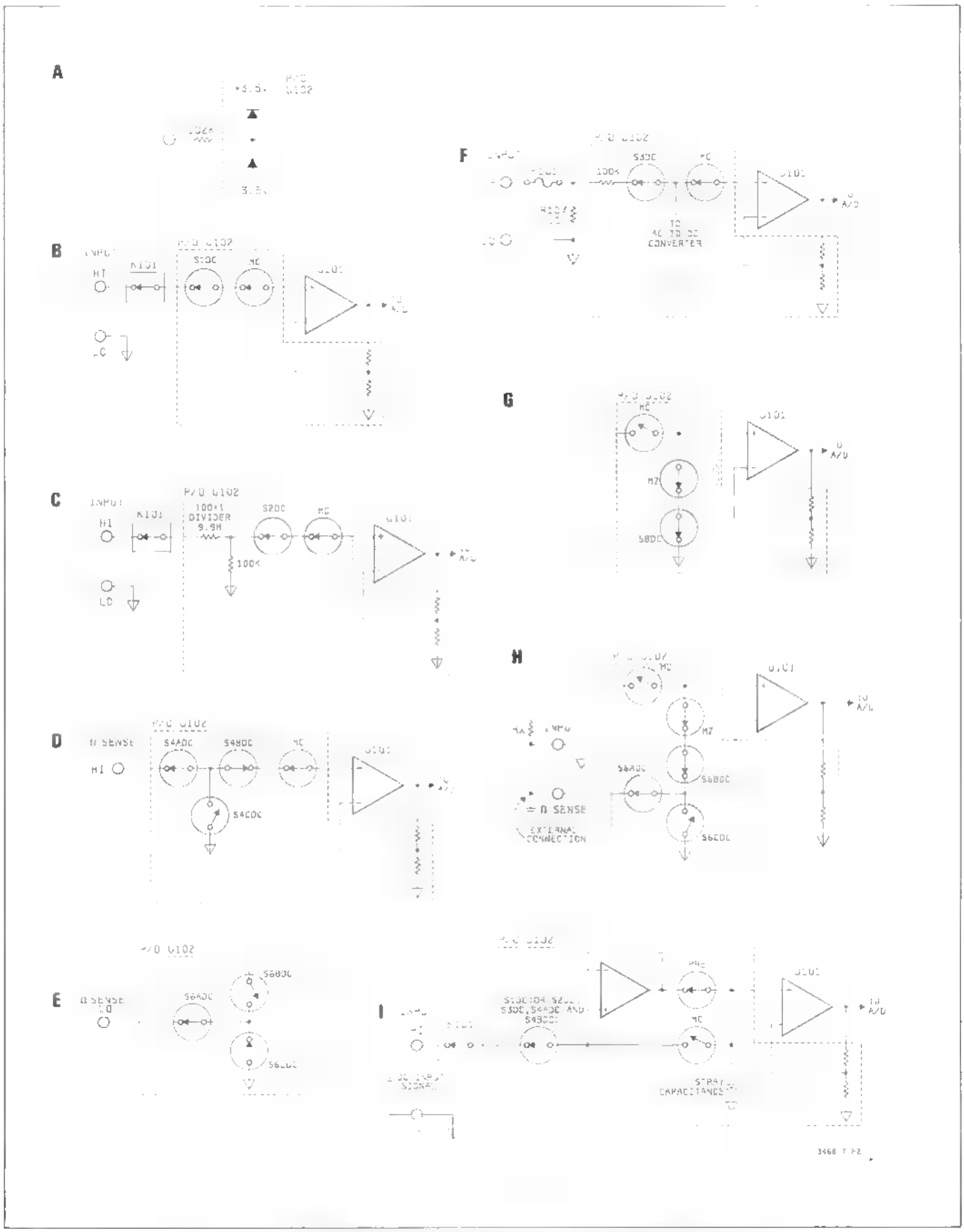


Figure 7-F-2. Simplified Schematic Of The Input Switching Circuitry

connected low ohms sense and lo input leads. After the offset measurement is made, switch MC and S6CDC closes and switch MZ, S6ADC, and S6BDC opens. Switch S6CDC is used to to connect the junction of switch S6ADC and S6BDC to ground, shunting any possible voltage on the junction to ground. (Note: MOSFET switches S6ADC, S6BDC, and S6CDC are in U102.)

7-F-15. Pre-Charge Stage (Figure 7-F-2I). A small stray capacitance exists in U102 between the input of the DC/Ohms Input Amplifier and ground. During ■ zero measurement (measure zero in the Autozero Function), this capacitor is at zero volts. After the offset measurement, the input to the 3468A is applied to the Input Amplifier and the capacitor is charged to the input voltage. This charging may temporarily load down the input voltage and ■ wrong reading is taken. To prevent this, the input of the Input Amplifier is pre-charged to the input voltage before the input measurement is made. This is done by the Pre-Charge Amp and MOSFET Switch PRE (both in U102). The operation is as follows:

a. After the zero measurement is made, switch PRE closes (switch MC is still open).

b. The input voltage is connected to the Pre-Charge Amp using the input paths.

c. Since the Pre-Charge Amp is ■ X1 gain amplifier, a voltage with the same polarity and value ■ the input voltage is applied through PRE to the DC/Ohms Input Amplifier. This pre-charges the stray capacitor to the input voltage.

d. Switch PRE then opens and MC closes. An input measurement is then made.

e. The same occurs before the next input measurement.

7-F-16. DC/Ohms Input Amplifier. The purpose of the DC/Ohms Input amplifier, in conjunction with the Input Switching Circuitry, is to condition the 3468A's input signals. The conditioning is done to apply the same full scale 10V dc voltage to the A/D Converter for all DC Volts, DC Current, and Ohms full scale inputs. This is done by configuring the amplifier to a gain of X3.33 or X33.3. The gains used in the 3468A's different ranges (in the DC Volts, DC Current, and Ohms Functions) are shown in Figure 7-F-3.

7-F-17. ■ Current Source

7-F-18. General. The purpose of the Ohms Current Source is to provide ■ stable current for resistance measurements. The current is applied to the unknown resistance and the resultant voltage drop across the resistance is measured. Since this voltage drop is directly proportional to the unknown resistance, the resistance value is determined by the 3468A's Main Controller from the voltage reading.

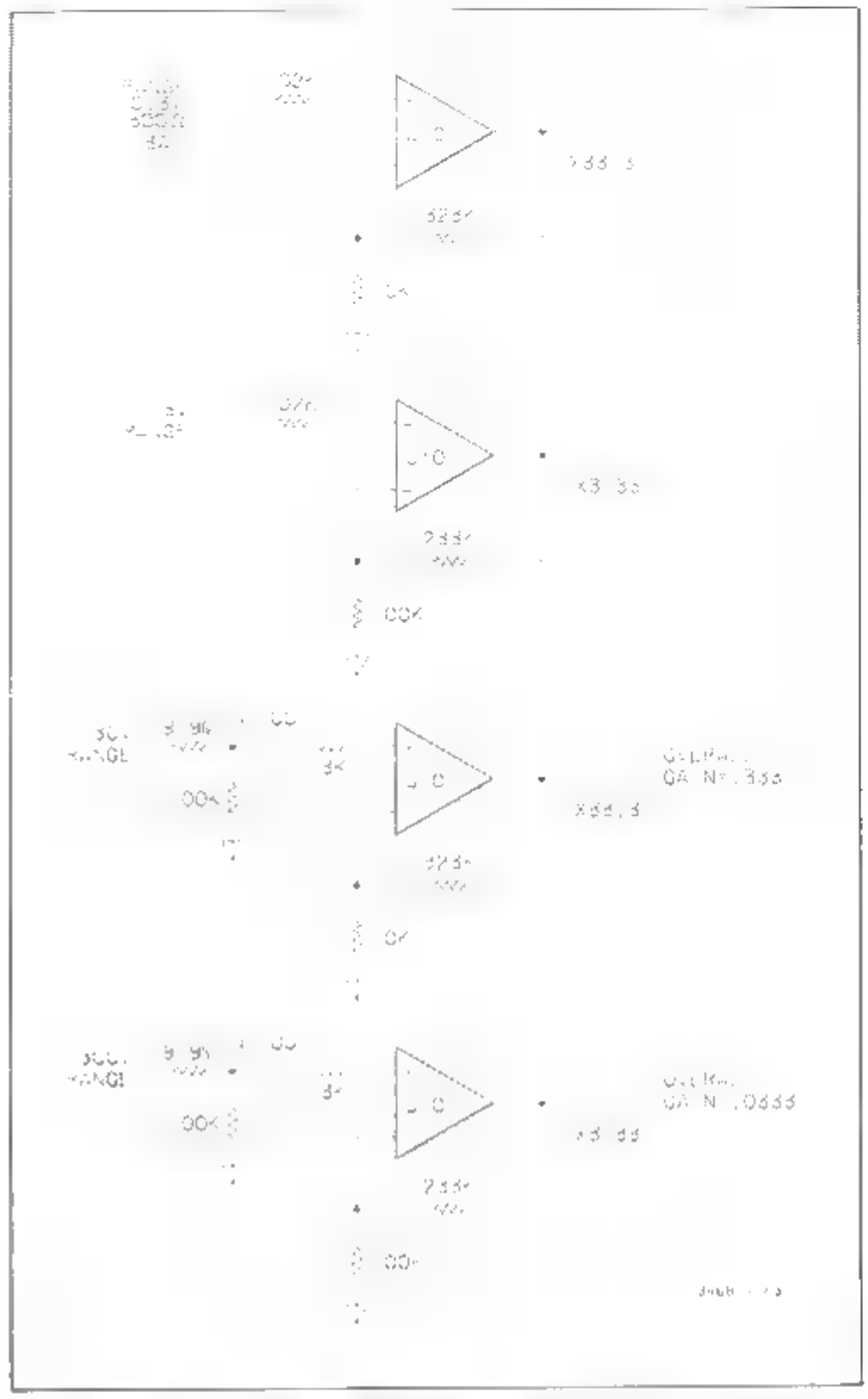


Figure 7-F-3. Simplified Schematic Of The DC/Ohms Input Amplifier

7-F-19. The Ohms Current Source consists of the following circuitry: Voltage Splitter (Voltage Reference), Buffer, Range Resistors, Output FET, Control Amp (Gate Bias Amplifier), Output MOSFET, and Overvoltage Protection. In addition to these, ■ number of MOSFETS are used as switches (to select various gain determining resistors). All the previously mentioned FETs are inside U102 which also controls the FET switches. The following paragraphs explain how the ohms current is generated and how the ohms circuitry operates. Refer to Schematic 1 and Figure 7-F-4 for the explanation.

7-F-20. Current Generation. The explanation on how current is generated is as follows:

a. The Voltage Splitter's (U201) output is +12V (or 8.4V for the 30M ohm Range only) which is applied to the positive terminal of Buffer U202. The reference output, which is applied to the positive terminal of the Output FET Control Amp U203, is divided down to +8V,

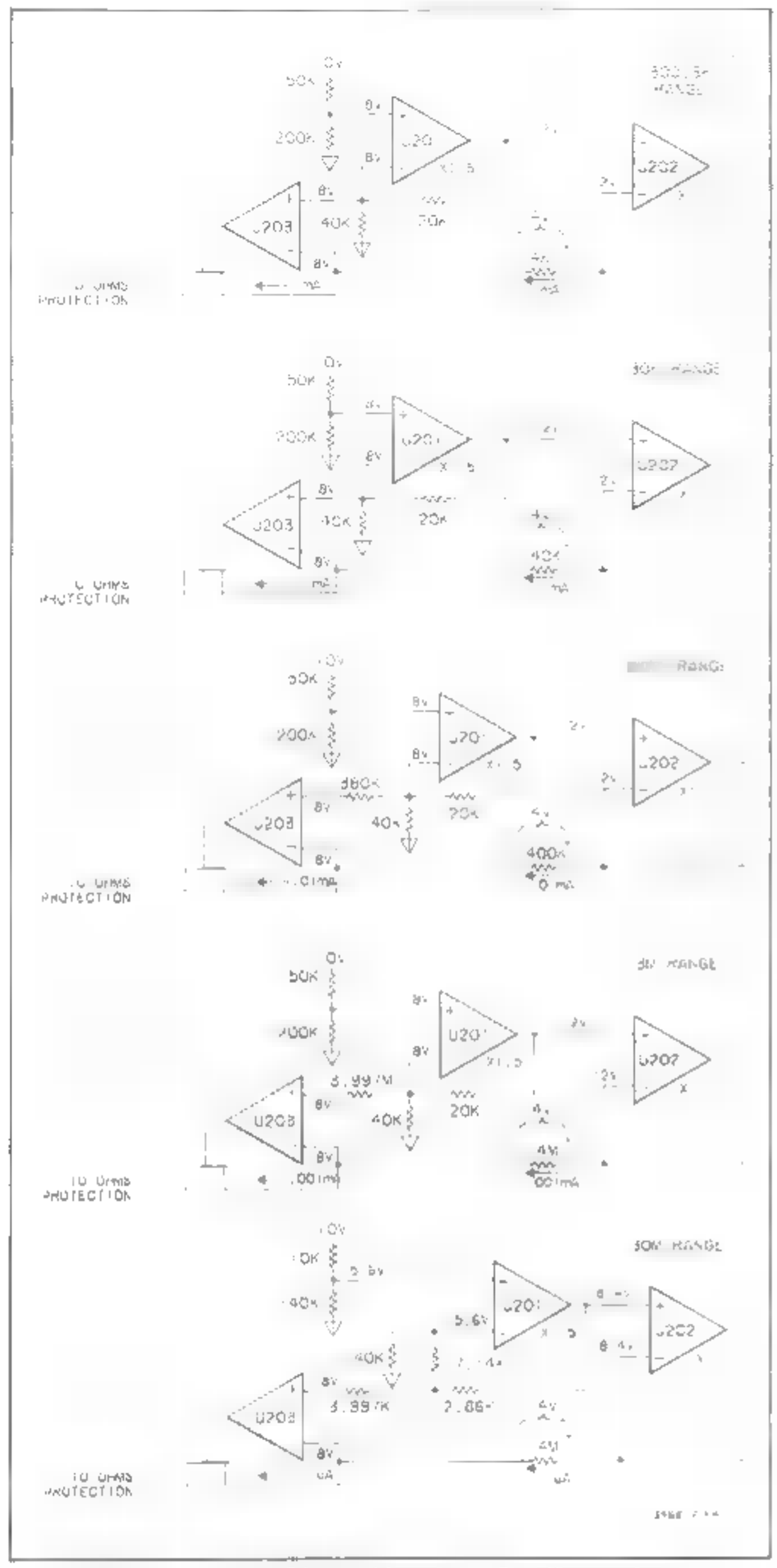


Figure 7-F-4. Ohms Circuitry Configuration

irrespective of range, by feedback resistors RR3 and RR4 in conjunction with R201.

b. The output of the Buffer is +12V (or +8.4V for the 30M ohm Range only) which is applied to one side of either Range Resistor RR5, RR6, RR7, or RR8 (dependent on the selected range). The other side of the Range Resistors is applied to the Output FET Control Amp.

c. Since the Output FET Control Amp is ■ high gain operational amplifier with its non-inverting terminal at +8V, its inverting terminal must also be +8V (the inverting terminal draws little or no current). This makes the resultant voltage drop across the Range Resistors +4V (or +.4V for the 30M ohm Range).

d. A current is then generated with its value proportional to the value of the Range Resistor and the voltage drop across the resistor.

e. The current is applied to the unknown resistor through the Output MOSFET (in U102), High Voltage Protection Cicuitry, and the HI INPUT Terminal. The 3468A's Ohms Ranges, Ohms Currents, Range Resistors, and selected MOSFET Switches are listed in Table 7-F-1.

Table 7-F-1. Ohms Current and Ranges

Ohms Range	Ohms Current	Range Resistor	Resistor Voltage	FET Switches Enabled
300-3K	1mA	4K (RR5)	4V	S0R,S2R,S3R, S6R,S7R,S14R
30K	.1mA	40K (RR6)	4V	S0R,S2R,S3R, S8R,S9R,S14R
300K	.01mA	400K (RR7)	4V	S0R,S2R,S4R, S10R,S11R
3M	1uA	4M (RR8)	4V	S0R,S2R,S12R, S13R
30M	.1uA	4M (RR8)	.4V	S1R,S5R,S12R, S13R

7-F-21. Voltage Splitter (U201). The following explains the Voltage Splitter (Reference) Circuitry.

a. The Voltage Splitter is ■ X1.5 gain non-inverting amplifier with an output of +12V (for the 300 ohm to 3M ohm Ranges) or +8.4V (for the 30M ohm Range).

b. The gain is determined by feedback resistors RR3, RR4 (both in U102), and R201. Since the total value of RR3 plus RR4 is 20K ohm and R201 is 40K ohm, the non-inverting gain is X1.5. (The gain is: [20K/40K] + 1 = 1.5).

c. The +12V output is generated by applying +8V to the amplifier input (8*1.5 = 12). The +8V is determined by the +10V Reference (from the 3468A's Reference Circuitry, see paragraph 7-F-49d) and voltage divider RR0, RR1, and RR2. The sum of RR1 and RR2 is 200K ohm and RR0 is 50K ohm resulting in ■ voltage drop across the resistors +8V and +2V, respectively. The +8V is applied through FET Switch S0R to U201.

d. The +8.4V output is generated by applying +5.6V to the amplifier input (5.6*1.5 = 8.4). The +5.6V is also determined by the +10V Reference (from the 3468A's Reference Circuitry) and voltage divider RR0, RR1, and RR2. In this case the voltage drop across RR2 (which is +5.6V developed across 140K ohm) is applied through FET Switch S1R to U201.

7-F-22. Buffer (U202) and Range Resistors (RR5 to RR8). The Buffer is ■ non-inverting X1 gain amplifier

with its output at either +12V or +8.4V (on the 30M ohm Range only). The gain is selected by either MOSFET Switch pairs S6R and S7R, S8R and S9R, S10R and S11R, or S12R and S13R. The Range Resistors are used to determine the different ohms current values. Refer to Table 7-F-1 to determine which switch and resistor is selected for the different ohms ranges.

7-F-23. The Output FET Control Amplifier (U203) and the Output MOSFET (in U102) form a feedback circuit used to boost the output impedance of the Output MOSFET. The FET is normally biased into saturation, and in conjunction with the open loop gain of U203 and the Range Resistors results in a high output impedance of the Ohms Current Source. A high output impedance is necessary to prevent measurement nonlinearities.

7-F-24. Overvoltage Protection Circuitry. The circuitry is used to protect the Ohms Current Source from high voltages inadvertently applied to the 3468A's Input Terminals (when the multimeter is in the Ohms Function). The following explains the circuitry operation.

a. If a large positive voltage is applied to the 3468A's HI INPUT Terminal, the voltage is applied through R204 and L201 to the cathode of CR201. Since the cathode voltage of CR201 is higher than the anode voltage, the diode is reverse biased. This prevents the large input voltage from damaging the current source.

b. If a large negative voltage is applied to the 3468A's HI INPUT Terminal, the voltage is dropped across R204, L201, and CR201, and across R203, and R202 to diode connected FET Q205. This makes Q205 conduct and in turn clamps the base of Q202 at -.7V (one diode drop). This voltage along with negative collector to base voltage forces Q201, Q202, Q203, and Q204 to turn on. Transistors Q201 and Q203 conducts no more current than the circuit which generates the ohms current (on a given range). The circuit that generates the ohms current cannot tell the difference between ■ valid unknown resistance and the large negative input voltage. Most of the large input voltage is dropped across R202 and R203.

c. R204 and L201 shape the initial current pulse to limit the current densities seen by the semiconductors in the current source under static discharge conditions.

7-F-25. AC to DC Converter

7-F-26. The purpose of the AC to DC Converter is to convert the 3468A's ac inputs (volts or current) to dc volts. The converter output is +3.00000V dc for all full-scale ■ inputs with the output applied to the A/D Converter. All ac ranging is done in the AC to DC Converter.

7-F-27. The AC to DC Converter consists of three amplifier stages and ■ True RMS Converter. The purpose of the amplifier stages is to provide the same full scale input voltage to the RMS Converter for all full scale ac inputs, and to be ■ buffer between the converter and the ■ inputs. The True RMS Converter does the actual ac to dc conversion. The following explains the circuitry operation.

7-F-28. Amplifier Stages. Refer to Figure 7-F-5 and Schematic 2 for the following explanation.

a. The first amplifier stage (U301A) is an inverting amplifier with gains of X.001, X.1, or X1 (dependent on the ac range and function selected). The gains are determined by resistors RA1, RA2, RA3, and RA11 (all in U102; RA11 is shown on Schematic 1), as shown in Figure 7-F-5. Capacitor C302 and resistor R305 are used for high frequency compensation (for flat gains at high frequency). The gain determining resistors are selected by MOSFETS S1AC through S6AC, and S11AC (all in U102) which operate as switches. The gains of the amplifier and FETs selected for the ac functions are listed in Table 7-F-2.

b. The second amplifier stage (U301B) is an inverting amplifier with gains of X.4 or X4 (dependent on the ac range and function selected). The gains are determined by resistors RA5, RA6, RA7, and RA8 (all in U102), as shown in Figure 7-F-5. The gain determining resistors are selected by FETs S7AC to S10AC (all in U102) which operate as switches (see Table 7-F-2). Resistor RA9 (in U102) makes sure the amplifier has the same high frequency response in X4 gain as in X.4 gain. Resistors R306 and R307, and C310 and C313 are used to filter the +15V and -15V power supplies, respectively.

c. The third amplifier stage (U302) is ■ non-inverting amplifier with ■ gain of X25 in all ac ranges and functions. The output of the amplifier is applied to the RMS Converter and is 3V RMS for all full scale ac inputs in all ac functions and ranges. Capacitor C305 is used for high frequency compensation (for flat gains at high frequency).

Table 7-F-2. AC Amplifier Gains

Function and Range	Stage 1 Gain	Stage 2 Gain	Total Gain	Switches (FETs) Enabled
ACV 300mV	.1	4	10	S2AC,S4AC,S5AC, S8AC,S10AC
ACV 3V	.1	.4	1	S2AC,S4AC,S5AC, S7AC,S9AC
ACV 30V	.001	4	.1	S1AC,S3AC,S6AC, S8AC,S10AC
ACV 300V	.001	.4	01	S1AC,S3AC,S6AC, S7AC,S9AC
ACI 300mA	1	4	100	S4AC,S5AC,S8AC, S10AC,S11AC
ACI 3A	1	.4	10	S4AC,S5AC,S7AC, S9AC,S11AC

7-F-29. True RMS Converter (U303). The True RMS Converter's output is a positive dc voltage with its value

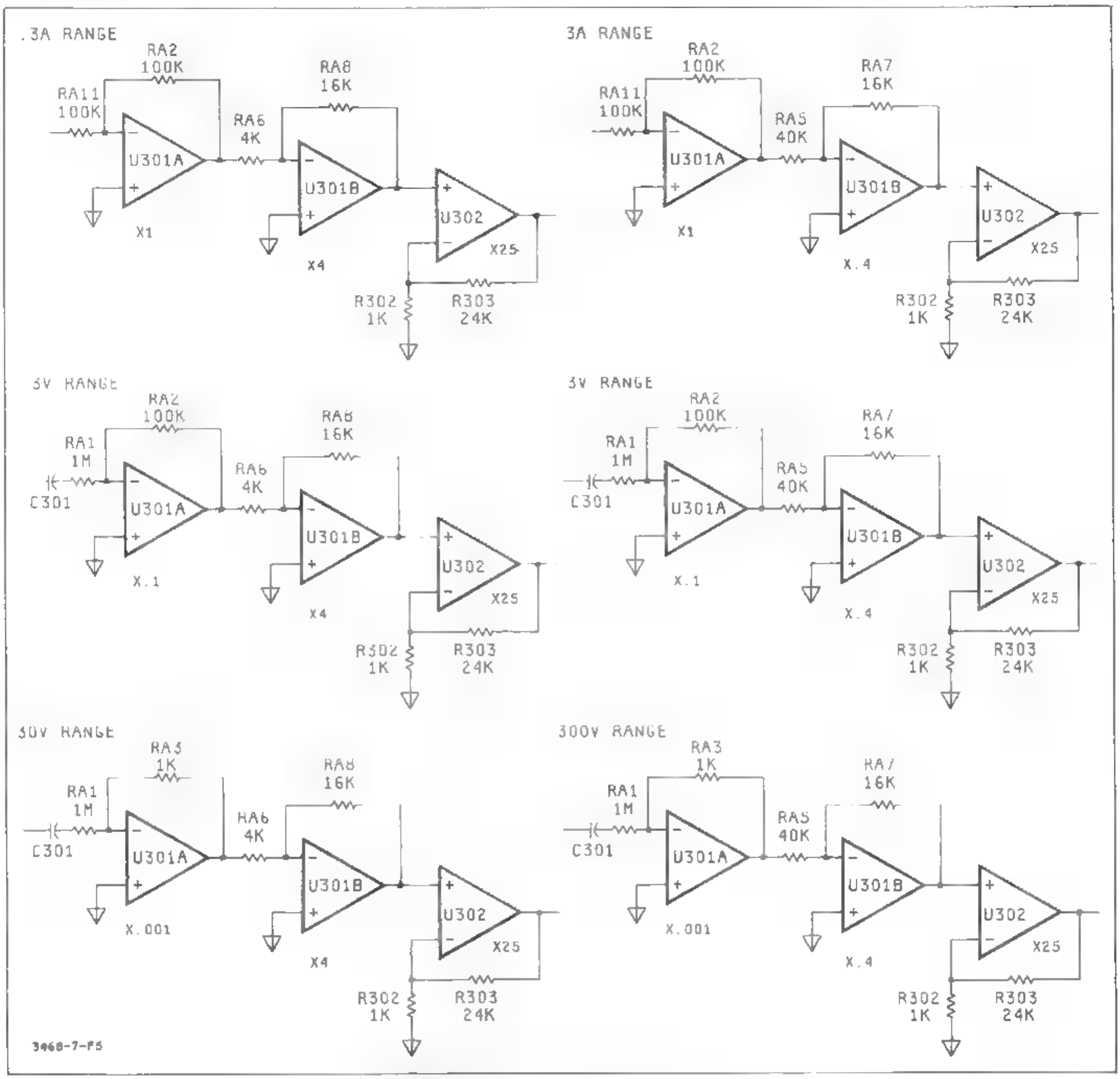


Figure 7-F-5. AC Gain Configurations

equal to the true rms value of the input. For example, a sine wave input of 1V RMS ac generates a +1V dc output.

7-F-30. Refer to Schematic 2. The RMS Converter has one major stage that does the actual conversion and a buffer (used as an output stage). The converter stage and the buffer are externally connected by R304. Pin 9 of U303 is the input to the buffer and pin 10 is the output of the converter stage. The gain of the buffer is X1 which is internally set.

7-F-31. A/D Converter

7-F-32. General. The A/D Converter is used to change dc voltages to digital information. The circuitry consists of an Integrator (U401 and associated circuitry), Voltage Reference (CR401 and associated circuitry), and the A/D Hybrid (U403). The A/D Converter operation is controlled by the Main Controller (U501).

7-F-33. The A/D conversion method used by the 3468A is called Multi-Slope II and has two operating states:

Runup and Rundown. The 3468A's most significant digits are determined during runup (see paragraph 7-F-41) and the least significant digits are determined during rundown. The integration time depends on the selected Number Of Digits Displayed (3 1/2, 4 1/2, or 5 1/2). To help understand Multi-Slope II, first consider the operation of the Dual-Slope Conversion method. This method is explained in the following paragraph.

7-F-34. Dual-Slope Conversion. In dual-slope conversion, an integrator capacitor charges for a fixed time period (as shown in Figure 7-F-6), which is done during runup. The charging rate and the resultant amplitude of the charge is proportional to the voltage applied to the integrator. The integrator capacitor is then discharged at ■ fixed rate determined by a known reference voltage and is done during rundown. Since the discharge rate is constant, the discharge time is proportional to the amplitude of the charge (input voltage). The amplitude level can then be determined by the discharge time.

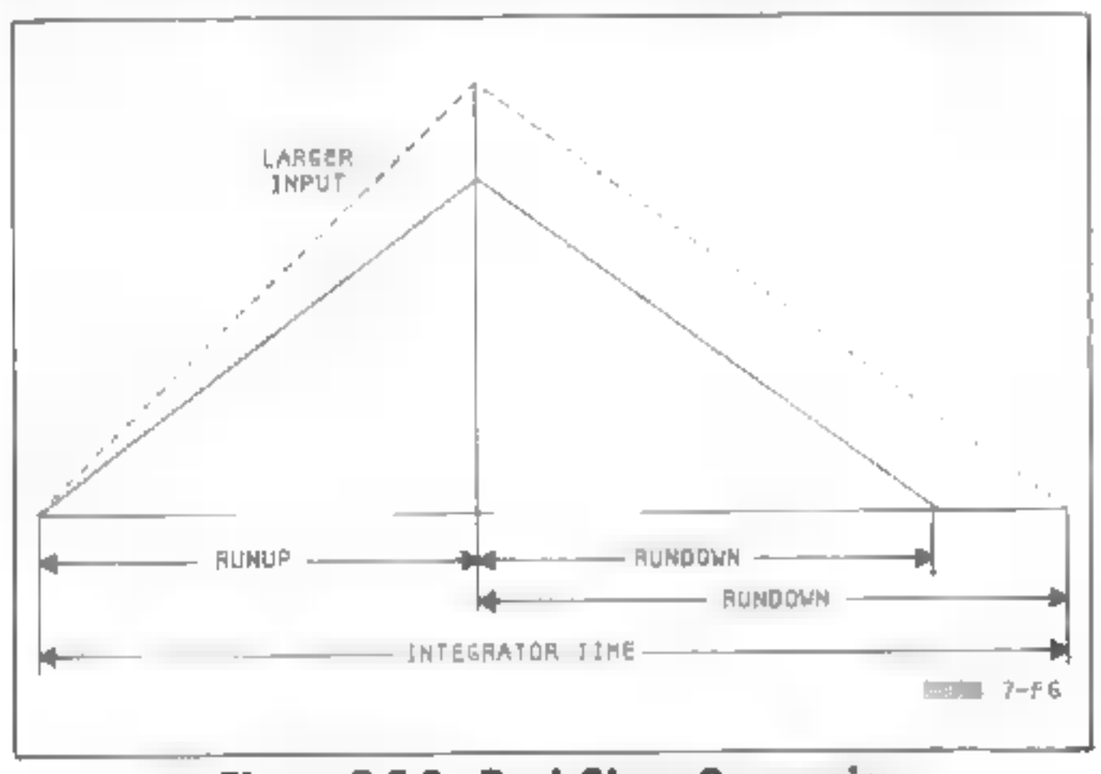


Figure 7-F-6. Dual Slope Conversion

7-F-35. Multi-Slope II Conversion. Multi-Slope II is similar to Dual-Slope in that a capacitor is charged and discharged by the input voltage and by known reference voltages. The following paragraphs explains the Multi-Slop II operation (runup and rundown).

7-F-36. Simplified Explanation of Runup. The Runup operation lasts for 317 A/D counts with one A/D count equal to 20 (24 in the 50Hz option) cycles of the ALE clock (Address Latch Enable at U501 pin 11). Each A/D count results in one A/D ramp (or slope) at the output of the A/D Integrator. The ▬ time is used in both the 5 1/2 and 4 1/2 digit mode (317 ramps), with 10 readings taken in the 5 1/2 digit mode (making the integration time longer, see paragraph 7-F-40). Only 34 ramps are used in the 3 1/2 digit mode. The ALE clock is generated by the Main Controller (U501, also known as the Main CPU). Refer to Figure 7-F-7 and Figure 7-F-8 for the following simplified explanation of the runup operation.

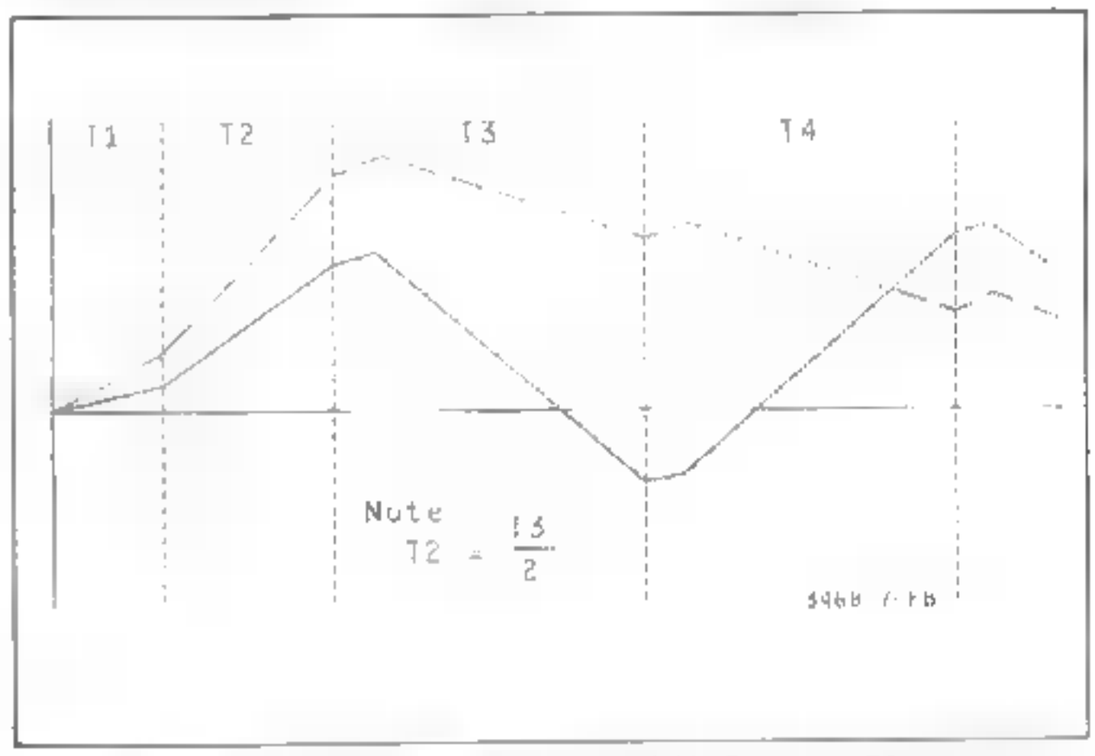


Figure 7-F-8. Integrator (U401) Output Slopes

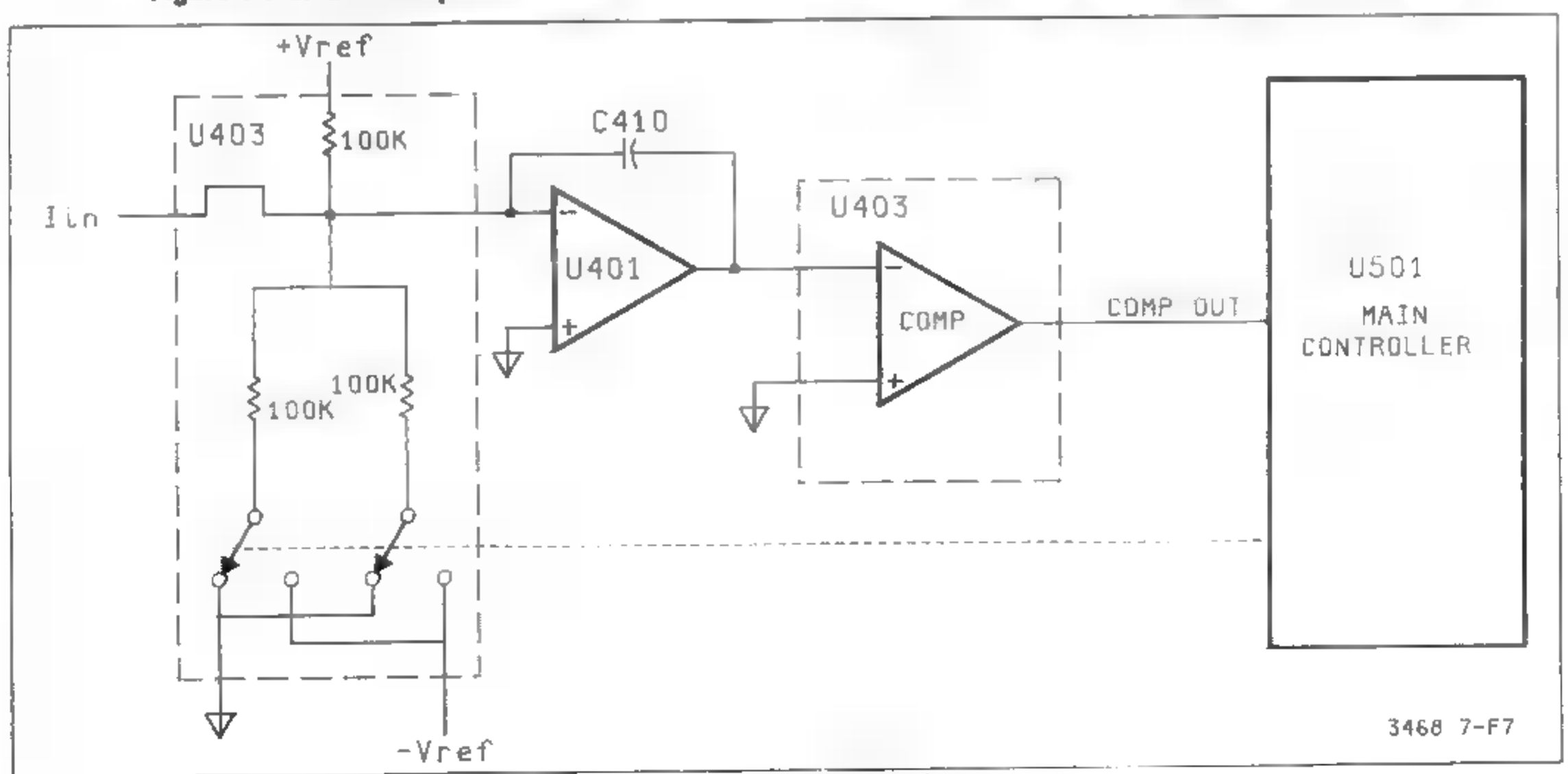


Figure 7-F-7. Simplified A/D Converter

a. When runup starts, the input voltage (A/D Converter input voltage, not instrument input voltage) is applied to integrator U401. The resultant input current (Iin) then charges integrator capacitor C410 and a certain slope (output of the integrator) is then developed. This happens at time period T1 (see Figure 7-F-8). (The input voltage is always applied during runup.)

b. After time period T1, a negative going current is applied to the integrator for ■ set time period. This current, in addition to the input current, charges C410. This generates a positive going output slope (the integrator output). The applied current makes sure that the output slope that follows will cross zero, whether the input current is positive or negative. The current is applied for time period T2.

c. After time period T2, the applied current (not the input current) is removed and a current of opposite polarity is then applied to U401 for new time period T3 (T3 is twice as long as T2). The newly applied current is the same value as the first applied current (at time T2), but at opposite polarity. The new current then charges C410 in the opposite direction (C410 is discharged). This is because the applied current is larger than the input current.

d. When time T3 is completed, the A/D Controller determines if the output slope crossed zero. If zero crossing is detected, a current with the same value, but at opposite polarity, as the previously applied current is applied. This current is the same current as the first applied current and is applied to the integrator for a new time period T4 (T4 is as long as T3). This current, in addition to the input current, then charges C410. Since both currents charge C410, the output slope becomes steeper and, as shown in Figure 7-F-8, crosses zero.

e. If no zero crossing (in step c) was detected (because of a larger input voltage), the same current as the previously applied current is applied for the new time period T4. The current is reapplied until zero crossing is detected. (This is shown as the dashed lines in Figure 7-F-8).

f. The operation in steps c and d, or in steps c and ■ continues until the runup operation is completed. The total runup operation lasts for 317 ALE ramps (or counts).

g. During the runup operation, a counter in the Main Controller increments during the positive going slope periods and decrements during the negative going slope periods. The counter, in effect, is used to determine the amount of charge added and subtracted from the input voltage. From that information, the most significant digits of the 3468A's reading is calculated.

7-F-37. Detailed Explanation of Runup. Figure 7-F-9 illustrates the 3468A runup operation in the 4 1/2 digit mode. Refer to the figure (and Schematic 3) for the runup explanation in the following steps. The solid lines (in the figure) showing the runup sequence is for a hypothetical input value. The dashed lines are for a larger hypothetical input value.

a. When runup starts, the integrator capacitor (C410) is charged by the input current (which is developed by the input voltage). The input current is applied to the negative terminal of integrator U401 (see Figure 7-F-7), and since the integrator is in the inverting configuration, the resultant output of U401 is positive (for positive input currents the slope is negative). The capacitor is charged for a short time period.

b. During the time period when only the input current is applied, no other currents charge C410. Since no other current is applied to U401 (except the input current), it is called a no-current condition and the resultant output slope is called slope S+0.

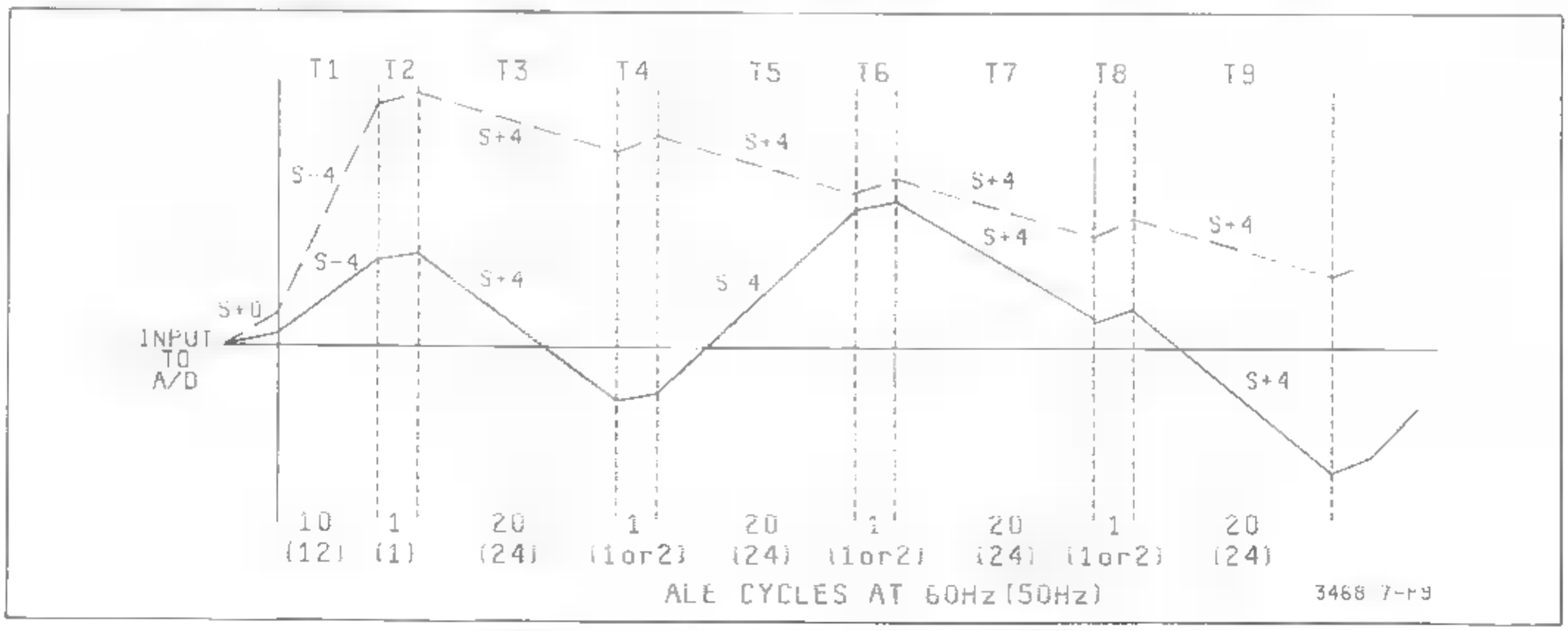


Figure 7-F-9. Runup Slopes (4 1/2 Digit Mode)

c. After the time period, a negative current (called S-4) is then applied to U401. This current develops ■ positive going output slope which is called slope S-4. The S-4 current is always the first current applied to the integrator after the input current is applied. The current is applied for 10 ALE cycles (12 ALE cycles in the 50 Hz option) and is for time period T1. Since the input current and the applied current in the example have the same polarity, both charge C410. If the input current was at opposite polarity, C410 will still be charged in the same direction but the output slope will be less steep. This is because the applied current (S-4) is normally larger than the input current.

d. After time period T1, current S-4 is removed. A no-current condition (slope S-0) will then exist for 1 ALE cycle (1 ALE cycle or sometimes 2 ALE cycles for the 50Hz option) during time period T2. The charge rate of Capacitor C410 is again determined by only the input current. Slope S-0 is also a no-current condition, as is slope S+0. The major difference is that the slopes are generated differently (see paragraph 7-F-39). Slope S-0 is selected since the previous no-current condition was slope S+0. The slopes alternate with each other (S+0, S-0, S+0, etc.) for each no-current condition.

e. When time T2 is completed, an S+4 current is applied for 20 ALE cycles (24 ALE cycles for the 50Hz option) during time period T3. The S+4 current has the same value as S-4, but at opposite polarity. This charges C410 in the other direction (i.e. the capacitor is discharged and then charged in the other direction). Time periods T3, and the T5, T7, and T9 periods that follow, are twice as long as time period T1 (20 or 24 ALE cycles instead of 10 or 12 ALE cycles).

f. After time T3, the S+4 current is removed and no current (slope S+0) is applied for time T4. Time T4 is as long as time period T2 (1 or 2 ALE cycles). This is also the same time for the S-0 or S+0 slopes that follow.

g. When T4 is completed, the Main Controller then determines if the output slope has crossed zero. Zero crossing occurs when the A/D comparator's output (CMP output at U403 pin 11) changes state. In the example, zero crossing is detected and current S-4 is applied for time T5 (20 or 24 ALE cycles).

h. After time T5, current S-4 is removed and no current (slope S-0) is applied for time T6. Since zero crossing was detected (during time T5), current S+4 is applied for time T7, after slope S-0 is completed.

i. When time T7 is completed, no curent (slope S+0) is applied for time T8. Since no zero crossing was detected, current S+4 is reapplied for time T9 (after slope S+0).

j. Since zero crossing was detected during time T9, current S-4 is applied (after slope S+0) for 20 (or 24) ALE cycles. Then S+4 is applied (since zero crossing is detected) and so on. This takes place until the runup time is completed (either current S+4 or S-4 is selected, dependent upon if and when zero crossing occurs).

k. Once the runup operation is completed, U501 then determines the 2 most significant digits of the reading. For other than ■ zero reading, the number of S+4 slopes will always be different than the number of S-4 slopes. For a perfect zero reading, the number of S+4 slopes will be the same ■ the number of S-4 slopes. This is represented in Figure 7-F-10.

7-F-38. Slope S+4 and S-4 Generation. The following explains how the curents for slopes S+4 and S-4 are generated.

a. **Slope S+4.** Refer to Figure 7-F-11. Note that both Y1 and Y2 paths are connected to ground. Since the summing node of the paths is a virtual ground and Y1 and Y2 are also connected to ground, no current

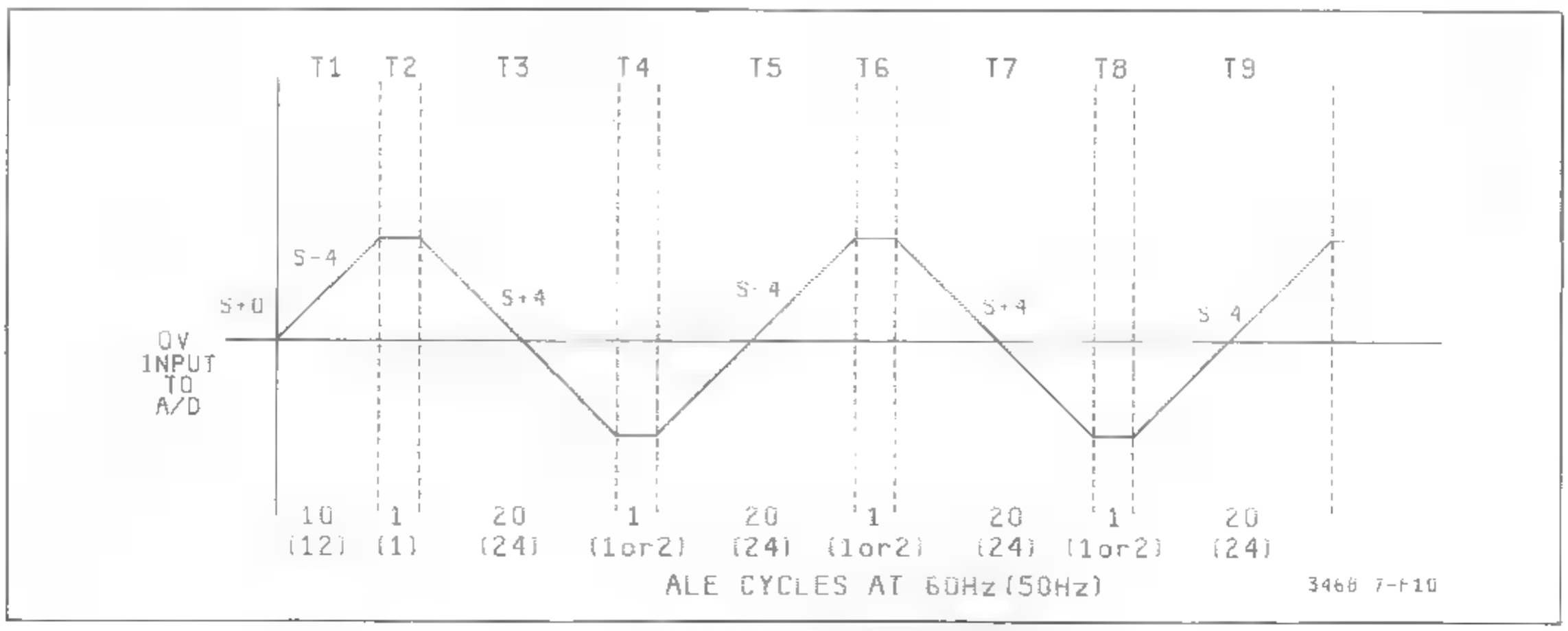


Figure 7-F-10. Runup Slopes For Zero Inputs (4 1/2 Digit Mode)

flows between the paths and the summing node. Current does flow from +Vref (Positive Reference Voltage) through ■ 100K ohm resistor into the integrator capacitor (connected to the negative terminal of U401). This generates ■ negative going output slope.

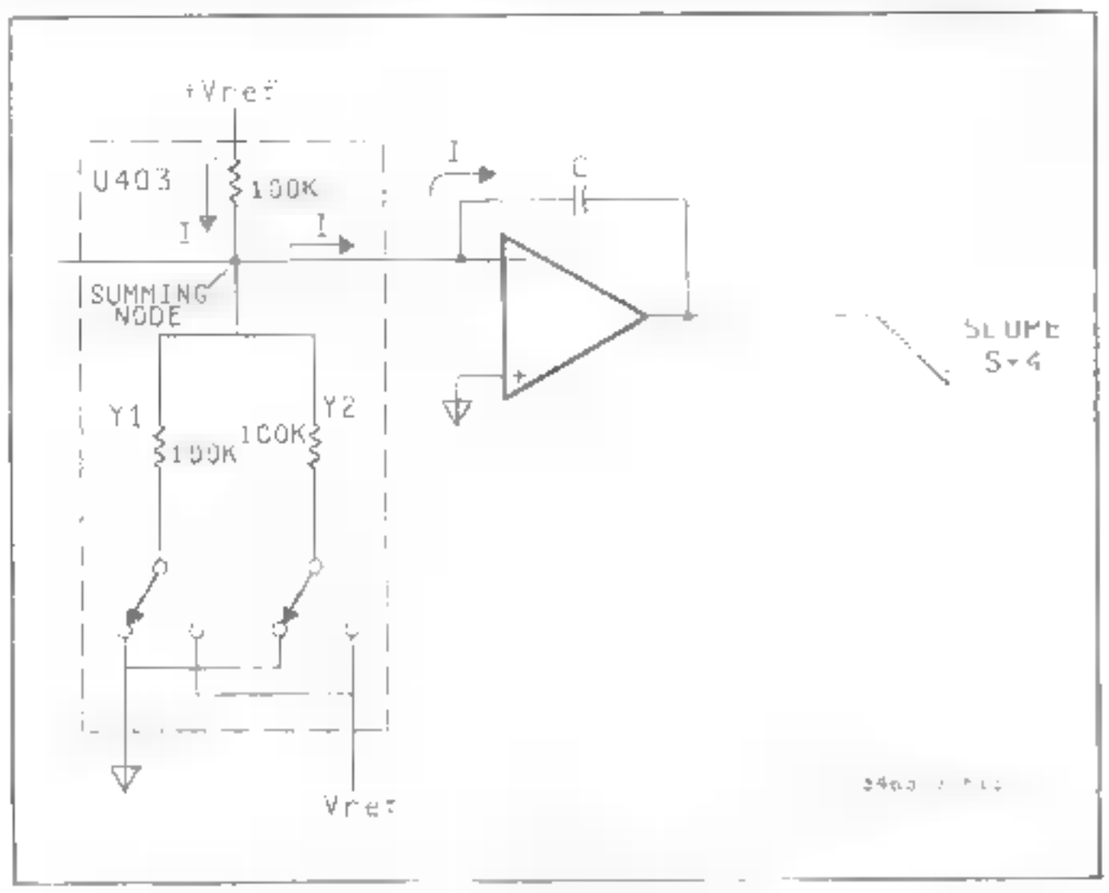


Figure 7-F-11. Slope S+4 Generation

b. **Slope S-4.** Refer to Figure 7-F-12. Note that both Y1 and Y2 paths are are connected to -Vref (Negative Reference Voltage). Since the summing node is a virtual ground, current flows from +Vref through a 100K ohm resistor and paths Y1 and Y2 to -Vref. Current also flows from the integrator capacitor (C) to -Vref. This current is generated because the total resistance of the Y1 and Y2 paths is smaller than the 100K ohm resistor from +Vref. The current from +Vref plus the current from the capacitor equals the total current through paths Y1 and Y2. Since the total resistance of paths Y1 and Y2 is 50K ohms, the current from +Vref (I1) and the current from the capacitor (I2) is half ■ large as the total Y1 and Y2 current (I3). The resultant output slope is positive.

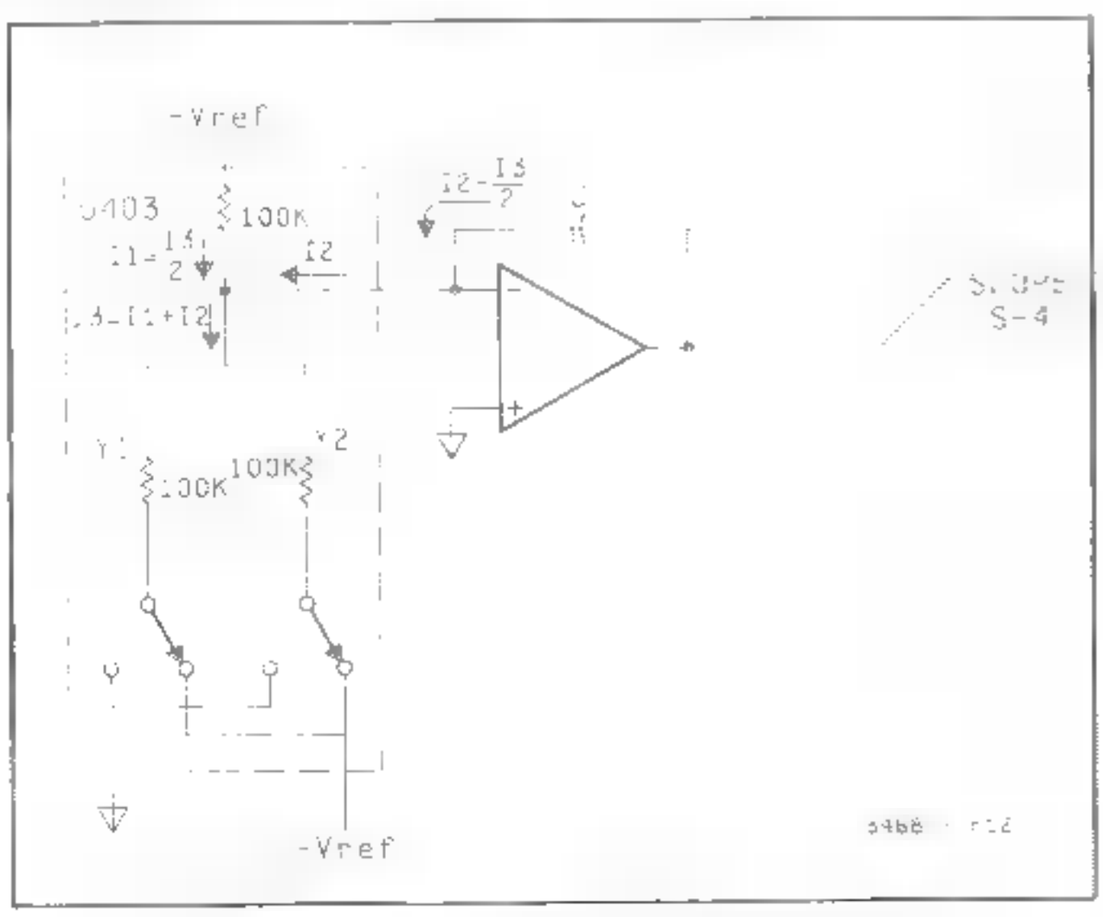


Figure 7-F-12. Slope S-4 Generation

7-F-39. Slope S+0 and S-0 Generation. Refer to Figure 7-F-13. Note that one side of a 100K ohm resistor (Y1 path) is connected to ground and the other side is connected to the summing node. Since the 100K ohm resistor from +Vref (Y3 path) and the 100K ohm resistor from -Vref (Y2 path) are also connected to the summing node, no current flows from the integrator capacitor (C). This is because the resistance value of path Y2 and Y3 is the same and makes the current value of paths Y2 and Y3 the same (but opposite polarity). This is true for both slopes S+0 and S-0. The only difference is that paths Y1 and Y2 are switched when the slopes are switched (Y1 to ground and Y2 to -Vref, or Y2 to ground and Y1 to -Vref).

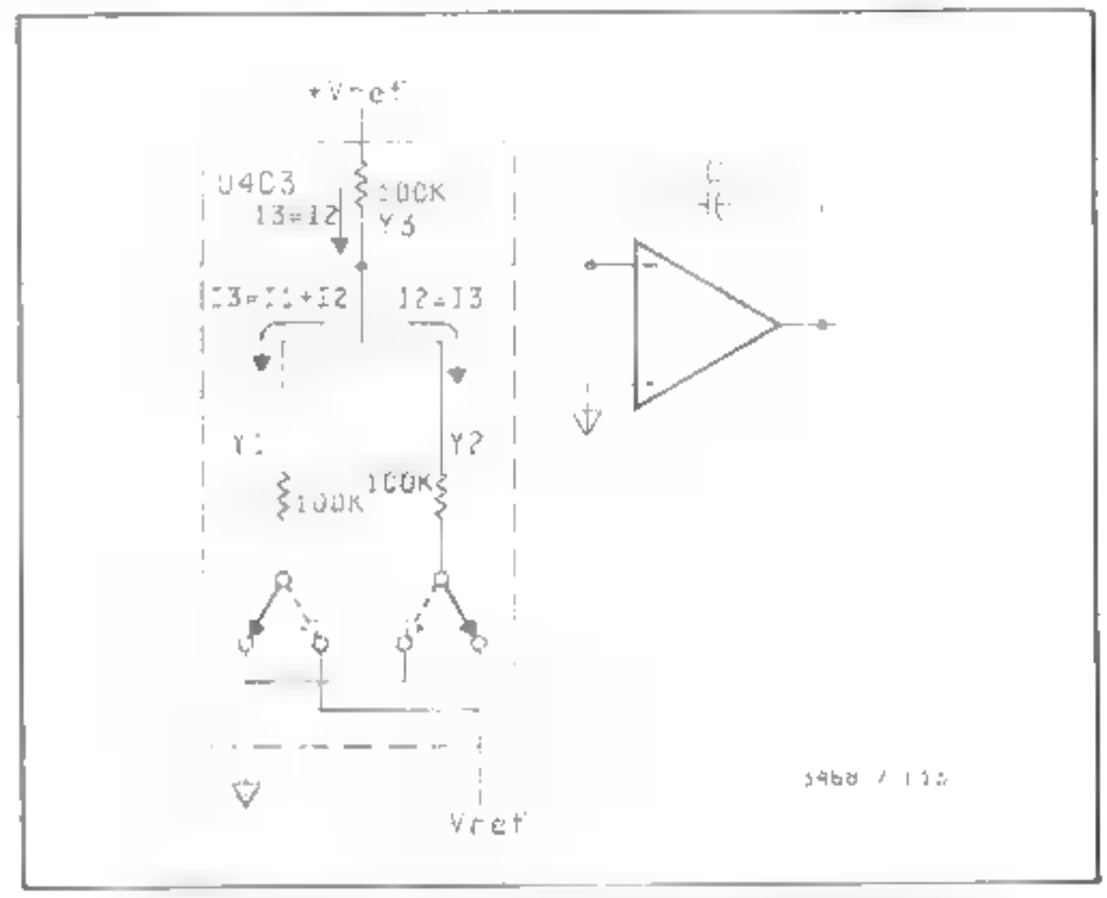


Figure 7-F-13. Slope S+0 and S-0 Generation

7-F-40. Runup Time. The runup time changes with the number of digits selected. For the 3 1/2 Digit mode, the time is 1/600 second (for both the 60Hz and the 50Hz options) and is called .1 PLC (Power Line Cycles). For the 4 1/2 Digit mode, the time is 1/60 second (1/50 second for the 50 Hz option) and is called 1 PLC. The 5 1/2 Digit mode is different. In this mode, ■ PLC is used for the runup time with the A/D operation repeated ten times. The resultant ten readings are then averaged and the answer becomes a single reading.

7-F-41. Digit Generation. When the 3468A is in the 4 1/2 and 5 1/2 Digit mode, the first two significant digits (of the reading) are determined during runup. In the 3 1/2 Digit mode, only the first digit is determined. In rundown, the three least significant digits ■ determined in all modes. A total of 5 1/2 digits ■ developed in both the 5 1/2 and 4 1/2 digit modes. Since only 4 1/2 digits are displayed in the 4 1/2 digit mode, the last digit in the mode is rounded off to the next higher digit.

7-F-42. Rundown. When runup is completed, the voltage at the A/D Converter's input is removed and the input is then connected to ground. The rundown operation then starts. Rundown is used to determine the three least significant digits of the 3468A's reading.

7-F-43. After runup, a voltage (or charge) remains on the integrator with its amplitude and polarity dependent on the last current applied (S+4 or S-4) and the input voltage (applied during runup). By obtaining the value of the remaining voltage, the least significant digits can then be determined. The voltage value is obtained by applying various currents to the integrator, and counting the number of times the currents have to be applied for the resultant output slopes of the integrator to cross zero.

7-F-44. The currents applied to the integrator are called the S-4, S+4, S-3, S+2, S-1, and S+1 currents and the resultant output slopes are the S-4, S+4, S-3, S+2, S-1, and S+1 slopes. Each one of the currents (S-4, S+4, etc.) are applied (in the given order) to the integrator a set number of times until zero crossing occurs. The only exception is the first S-4 current (see paragraph 7-F-45 step c). The first and second set of currents applied are the S-4 and S+4 currents, respectively. These currents have the same value as the S-4 and S+4 currents used in the runup operation, but are applied half as long. The S-4 and S+4 slopes are each 10 ALE cycles long (20 ALE cycles in runup) and are called half-ramps. The next currents applied (in order) are the S-3, S+2, and S-1 currents, with S-0 slopes applied between them.

7-F-45. Rundown time is separated into five time periods, as shown in Figure 7-F-14. Refer to the figure for the following explanation on the rundown operation.

a. When rundown starts, the polarity of the remaining voltage on the integrator is determined by the Main Controller (U501). The polarity is determined by the output state of the A/D comparator (CMP output at U403 pin 11). A high output level shows a positive voltage and a low level shows a negative voltage.

b. If it has been determined that the remaining voltage on the integrator is negative, S-4 currents are applied a number of times until zero crossing occurs (CMP output changes state). Since the S-4 currents can be applied (during time T1 in Figure 7-F-14) to a maximum of three ramps, the resultant output slope S-4 will normally cross zero with three or less S-4 currents applied. After zero crossing occurs, the current is removed within 10 ALE cycles (i.e. one half-ramp) after the S-4 slope crosses zero. If (after the current is removed) time T1 is not completed, a no-current condition remains (i.e., an S-0 slope) for the rest of time T1. No current is applied to keep the rundown time constant.

c. If the remaining voltage on the integrator is positive, current S-4 is applied for a short time and then removed. The current is applied for a short time because the current develops a positive output slope and the integrator voltage is also positive. Both the slope and the integrator voltage together could saturate the integrator. When Current S-4 is removed, no current (an S-0 slope) is then applied for the rest of time T1. Current S-4 is applied whether the integrator voltage is positive or negative. This is to make sure that the slopes that follow (slope S+4) will always cross zero and that the same transitions occurs for all readings.

d. The next current applied is positive S+4 current. Its value is the same as S-4, but in the opposite direction. The current is applied until slope S+4 crosses zero. The current can be applied (during time T2) a maximum of three ramps. This makes time T2 the same as time T1. The S+4 currents are also removed within 10 ALE cycles after the S+4 slope crosses zero. Here again, no current is applied (slope S-0) for the remainder of time T2.

e. After time T2, the next current applied is negative S-3 current (its polarity is opposite of S+4). Because the

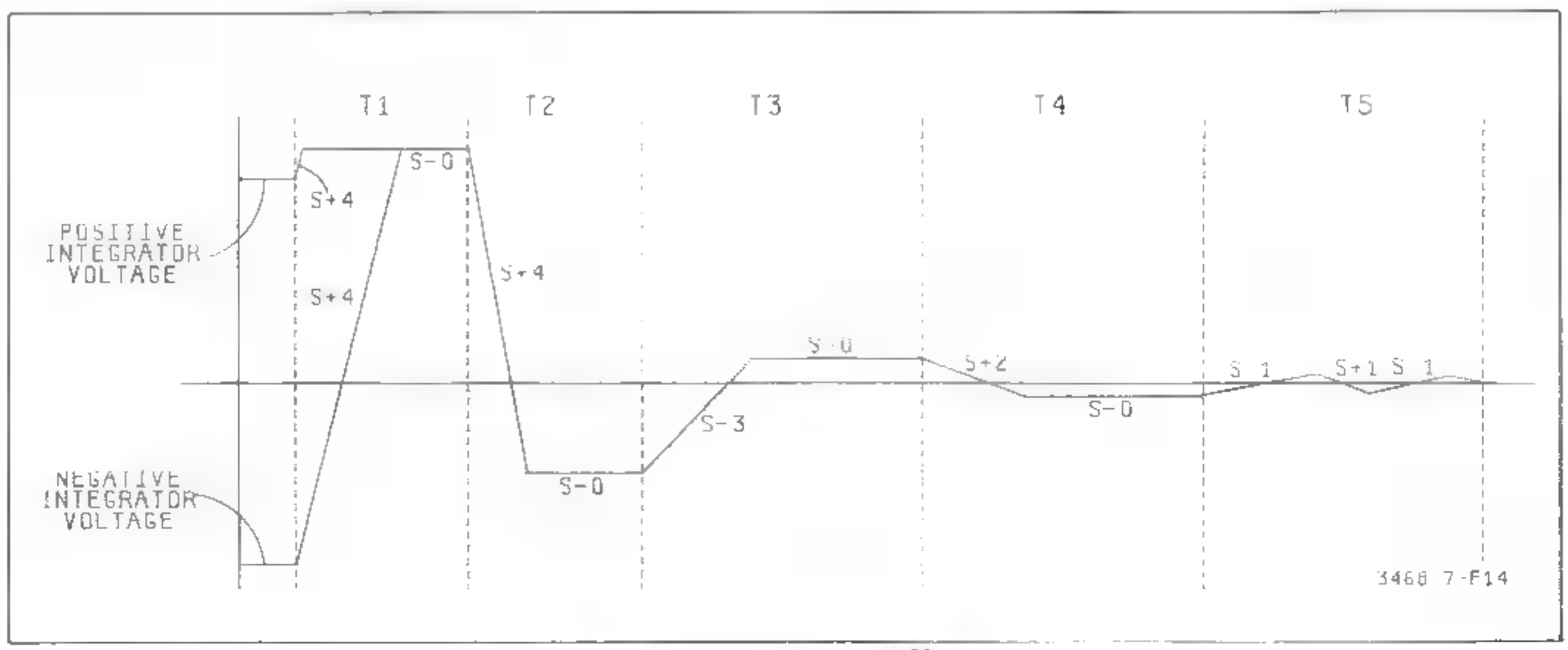


Figure 7-F-14. Rundown Slopes

value of an S-3 current is 1/10 the value of an S-4 current, the resultant S-3 slope is not as steep and takes a longer time to cross zero. This makes the maximum number of times the currents can be applied (during time T3) seven times instead of three. The S-3 current is also removed within 10 ALE cycles after slope S-3 crosses zero. Then no current (S-0) is applied for the remainder of time T3.

f. When time T3 is completed, positive current S + 2 is applied. This current is 1/10 the value of S-3 (1/100 of S-4) and in the opposite direction. The maximum number of times the S + 2 current can be applied is seven (as are S-3 currents). Time T4 has the same amount of time as T3. The S + 2 currents are also removed within 10 ALE cycles after slope S + 2 crosses zero. Then no current (S-0) is applied for the remainder of time T4.

g. The next current applied is negative S-1. This current is 1/10 the value of S + 2 (1/1000 of S + 4) and in the opposite direction. The current is applied until it crosses zero. The currents are also removed within 10 ALE cycles after slope S-1 crosses zero.

h. Once the S-1 currents are removed a positive S + 1 current is applied for 5 ALE cycles and is called one quarter ramp. This current is applied instead of no current and only happens after the S-1 slope. The current has the same value as S-1, but in the opposite direction. The currents are applied until zero crossing occurs and are removed within 5 ALE cycles after crossing zero.

i. After current S + 1 is removed, within 5 ALE cycles, current S-1 is reapplied. This new S-1 current is also applied until zero crossing occurs. After S-1 slope cross zero, current S + 1 is reapplied. After current S + 1 is removed, S-1 is applied, and so on. This takes place until time T5 (and rundown) is completed.

j. During the rundown time, a counter in the Main Controller counts the number of S-4, S + 4, S-3, S + 2, and S-1 slopes it takes for each set of slopes to cross zero. This is then used to calculate the 3 least significant digits of the 3468A's reading.

7-F-46. Integrator Offset Compensation. The A/D Integrator can have offsets which can prevent the S + 2 and S-1 slopes from crossing zero. To make sure the slopes will cross zero, the A/D's DAC (Digital to Analog Converter, R401 through R406) is turned on before the S + 2 currents are applied. The DAC is used to null out any offsets from the integrator.

7-F-47. The correct DAC setting is determined during the time when the S + 1 and S-1 currents are applied. These currents are applied after the first set of S-1 slopes have crossed zero (see paragraph 7-F-45, step g). Since both S + 1 and S-1 currents have the same amplitude, the S + 1 and S-1 slopes should have the same magnitude (i.e. zero crossing should occur at a certain time). If a difference in magnitude is noted by the Main Controller, the DAC is adjusted until the magnitude of the S + 1 and S-1 slopes are the same. This is illustrated in Figure 7-F-15. Refer to paragraph 7-F-66 for more information on the DAC.

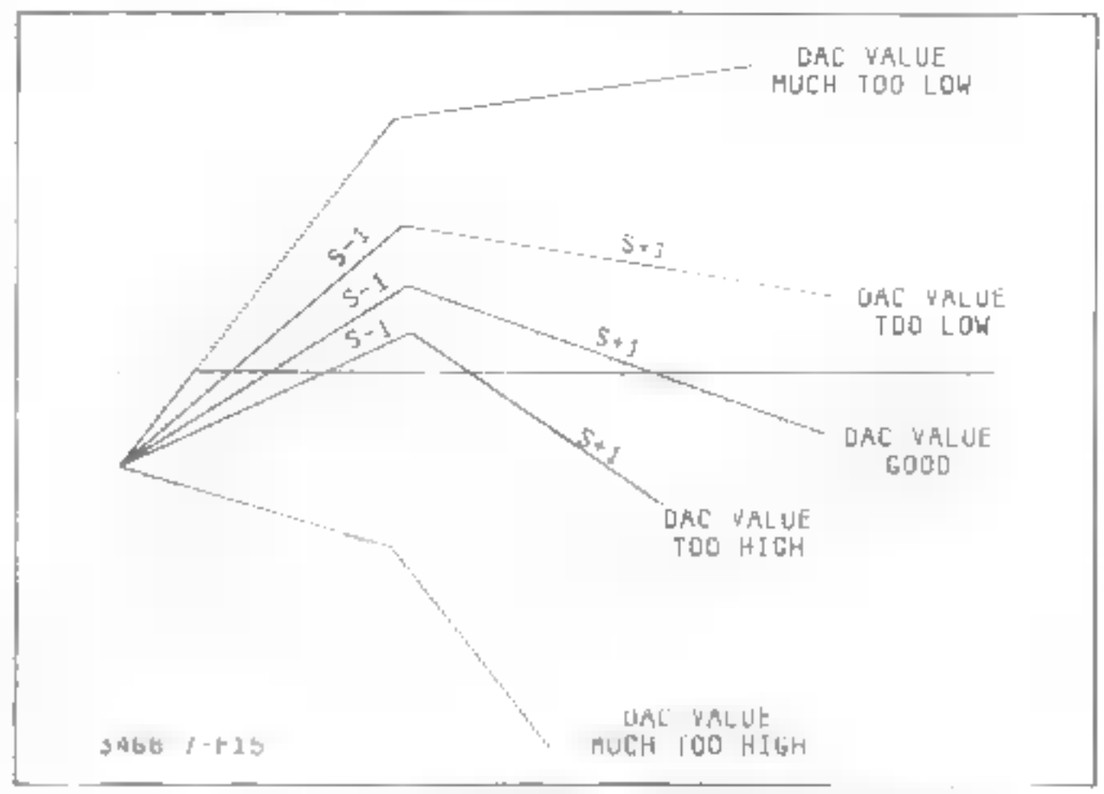


Figure 7-F-15. Determining the DAC Setting

7-F-48. Rundown Slope Generation. The S-4 and S + 4 slopes are generated the same way it is done for the runup operation (see paragraphs 7-F-38). The only difference is that they only depend on the applied S-4 and S + 4 currents, not the input current. The S-0 slope is generated the same way as the S-0 slope in runup (see paragraph 7-F-39). The S-3 and S-1 currents use the same circuitry configuration as the S-4 current (see Figure 7-F-12), but use different resistor values. The resistor values are such that the S-3 current is 1/10 the S-4 current and the S-1 current is 1/1000 the S-4 current. The S + 2 and S + 1 currents use the same circuitry configuration as the S + 4 current (see Figure 7-F-11). In this case, the resistor values chosen are such that the S + 2 currents are 1/100 the value of S + 4 current and S + 1 is 1/1000 the value of S + 4.

7-F-49. A/D Converter and Reference Circuitry. The A/D Converter Circuitry consists of the A/D Hybrid (U403), A/D Integrator (U401 and associated circuitry), and the Main Controller (U501). Since the Voltage Reference Circuitry (CR401, U405, U404, U402, and associated circuitry) uses part of the A/D Hybrid (for stability purposes) and since it is also used by the A/D Converter, it is considered part of the converter circuitry. Refer to Schematic 3 for the following explanation on the A/D Converter Circuitry.

a. **A/D Hybrid (U403).** The A/D Hybrid, shown in Figure 7-F-16, operates as follows:

1. The A/D Hybrid has, internal to it, various latches, decoders, and a clock generator. The decoders receive control information from the Main Controller, then decode the information and pass the new information to the latches. The latches then transfer the new information to the

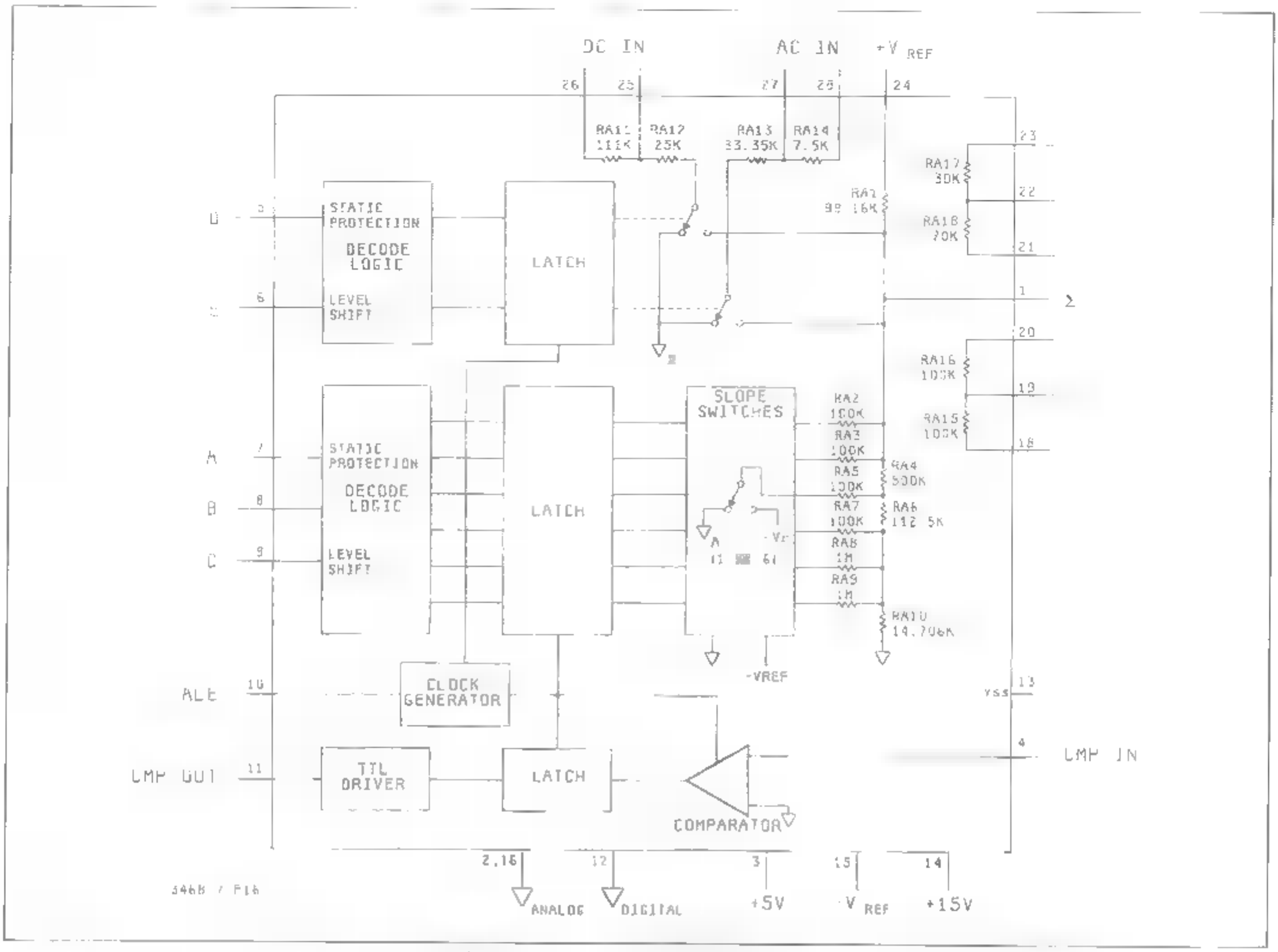


Figure 7-F-16. A/D Hybrid (U403)

various switches in the hybrid during each clock pulse. The clock pulses are generated by the clock generator which is syncronized by the ALE clock (from the Main Controller). The hybrid receives all its control information from ports P15 through P17, and P26 and P27 of the Main Controller (U501 pins 32 to 34, and pins 37 and 38). The information is transferred over the A, B, C, D, and E lines (U403 pins 5 through 9) of the hybrid.

2. The S-4, S+4, S-3, S+2, S-1, S+1, S-0, and S+0 currents are developed using resistors RA2 through RA10 in conjunction with the slope switches.

3. The A/D comparator is also inside the A/D Hybrid and its input is connected to the output of the A/D Integrator. The comparator updates its output during each clock pulse. Since the comparator's output is connected to a latch, the output is transferred to a TTL driver during each clock pulse. The TTL driver is ■ buffer which connects the output of the latch to the Main Controller.

4. Dependent on the function selected, the hybrid connects the DC/Ohms Input Amplifier's output or the AC to DC Converter's output to the A/D Integrator's (U401) input resistor (RA1 in U403). This is done by the input switches inside the hybrid.

b. **A/D Integrator (U401 and associated circuitry).** The A/D Integrator consists of an amplifier (U401) with capacitor feedback (C410). Since the amplifier is inverting, the output slopes of the integrator will be positive for negative input currents (and vice versa).

c. **Main Controller (U501).** The Main Controller controls the operation of the A/D Converter and the instrument. This includes the control of the runup and rundown operation, and selecting the correct currents (S-4, S+4, etc.). Refer to paragraph 7-F-52 for more information on the Main Controller.

d. **Voltage Reference.** The Voltage Reference provides three stable reference voltages: -10V, +10V, and ■ buffered -10V. The circuitry, shown in Figure 7-F-17, is explained as follows:

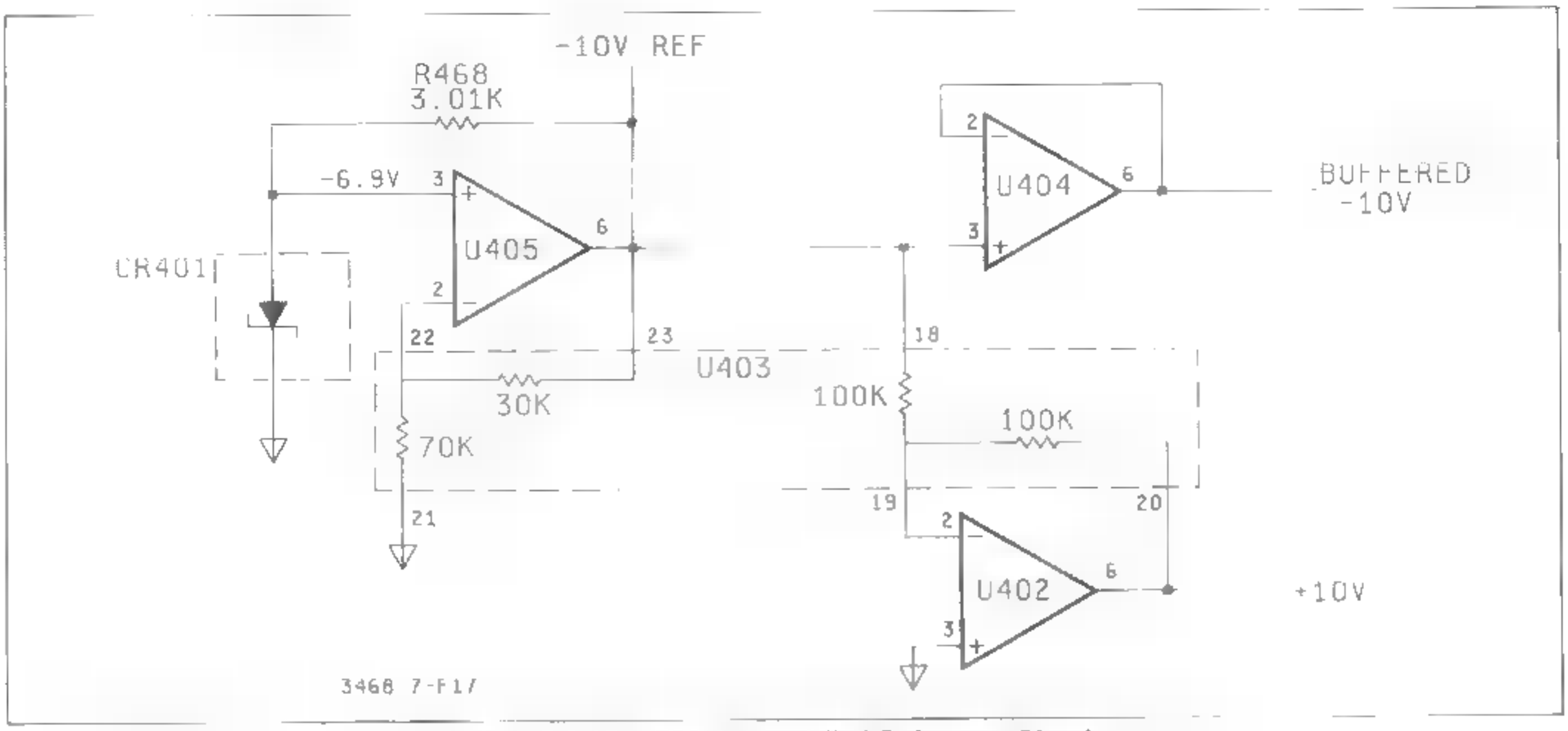


Figure 7-F-17. 3468A Simplified Reference Circuitry

1. The -10V reference voltage is used by the A/D Hybrid (U403) to develop stable and accurate S-4, S+4, S-3, etc. currents. The reference voltage is developed by non-inverting amplifier (U405) using feedback resistors in U403 and ▪ 6.9V reference diode (zener diode CR401). The reference diode is connected to the amplifier's positive terminal and determines the stabilty of the reference voltage. The feedback resistors for U405 are in U403 for good stability.

2. The buffered -10V is used by the A/D Hybrid as a stable -10V power supply. The voltage is developed by X1 gain non-inverting amplifier U404 and the -10V reference voltage.

3. The +10V reference voltage is used by the A/D Hybrid (in conjunction with the -10V reference) to develop the S-4, S+4, S-3, etc. currents. The +10V reference voltage is also used by the Ohms Current Source to develop a stable ohms current (see paragraph 7-F-21). The reference voltage is developed using inverting amplifier U402 and feedback resistors in U403.

7-F-50. ▪ Control Logic Circuitry

7-F-51. The 3468A Control Logic Circuitry controls the operation of the whole instrument, including front panel and remote operation. The major circuitry is the Main Controller Circuitry, consisting of a CPU (U501) and a Control ROM (U502). The operation of the Control Circuitry is descibed in the following paragraphs. Unless otherwise specified, refer to Schematic 3 for the explanation. The circuitry is described as follows:

a. Main CPU (U501) Circuitry - paragraph 7-F-52.
b. Control ROM (U502) - paragraph 7-F-53.
c. Power-On and Reset Circuitry - paragraph 7-F-54.
d. CMOS RAM - paragraph 7-F-55.
e. RAM Addressing - paragraph 7-F-56.
f. Reading the RAM - paragraph 7-F-57.
g. Sending Data to RAM - paragraph 7-F-58.
h. Keyboard Operation - paragraph 7-F-60.
i. Display Operation paragraph 7-F-61.
j. HP-IL Operation - paragraph 7-F-62.
k. Rear Panel Switch - paragraph 7-F-63.
l. A/D Converter Control - paragraph 7-F-64.
m. Input Hybrid Control - paragraph 7-F-65.
n. Digital to Analog Converter Operation paragraph 7-F-66.

7-F-52. Main CPU (U501) Circuitry. The operation of the CPU and associated circuitry is as follows:

a. The CPU has ▪ internal 128 bytes of RAM memory and a clock. The frequency and stability of the clock is determined by 6.003 MHz crystal Y501.

b. The Data Lines (D0 to D7) from the CPU are used as both Data Lines and the lower 8 bits of the Address Lines (A0 to A7). This is done by multiplexing the lines. The Address Lines are used to address the Control ROM, CMOS RAM, and the HP-IL Chip. The Data Lines send and receive data between the CPU and the Control ROM, CMOS RAM, and HP-IL Chip. The ALE (Address Latch Enable) line goes low to latch the lower 8 Address bits on U508. The Address bits are then sent to the Control ROM, CMOS RAM, and HP-IL Chip.

c. Other lines from the CPU are bi-directional Ports. The ports are used to control the A/D Converter Hybrid (U403) and Input Hybrid (U102), send information to the display, and send and receive data to the keyboard. Some ports (P20 through P23) are used as the upper Address bits, A8 through A11).

7-F-53. Control ROM (U502). The Control ROM is addressed when its $\overline{CE}$ line (Chip Enable at U502 pin 20) is low. The low comes from the CPU's $\overline{PSEN}$ line (Program Store Enable at U501 pin 9). Address A0 to A7 comes from latch U508. Address bits A8 to A11 comes from Ports P20 to P23 (U501 pins 21 to 24). Address bit A12 comes from Port P14 (U501 pin 31) of the CPU. When the ROM is addressed and enabled, data from the ROM is transfered to the Data Lines.

7-F-54. Power-On and Reset Circuitry. The Power-On and Reset Circuitry is used to reset the CPU after the 3468A is turned on, when the front panel TEST/RESET button is pressed, and if the CPU inadvertantly goes to a non-operational state. The circuitry operates as follows:

a. **Power-On Circuitry.** Refer to Figure 7-F-18 or Schematic 3. The Power-On Circuitry resets the CPU when the 3468A is turned on and when the >7V power supply (raw supply for the +5V supply) is low. The step by step operation is as follows:

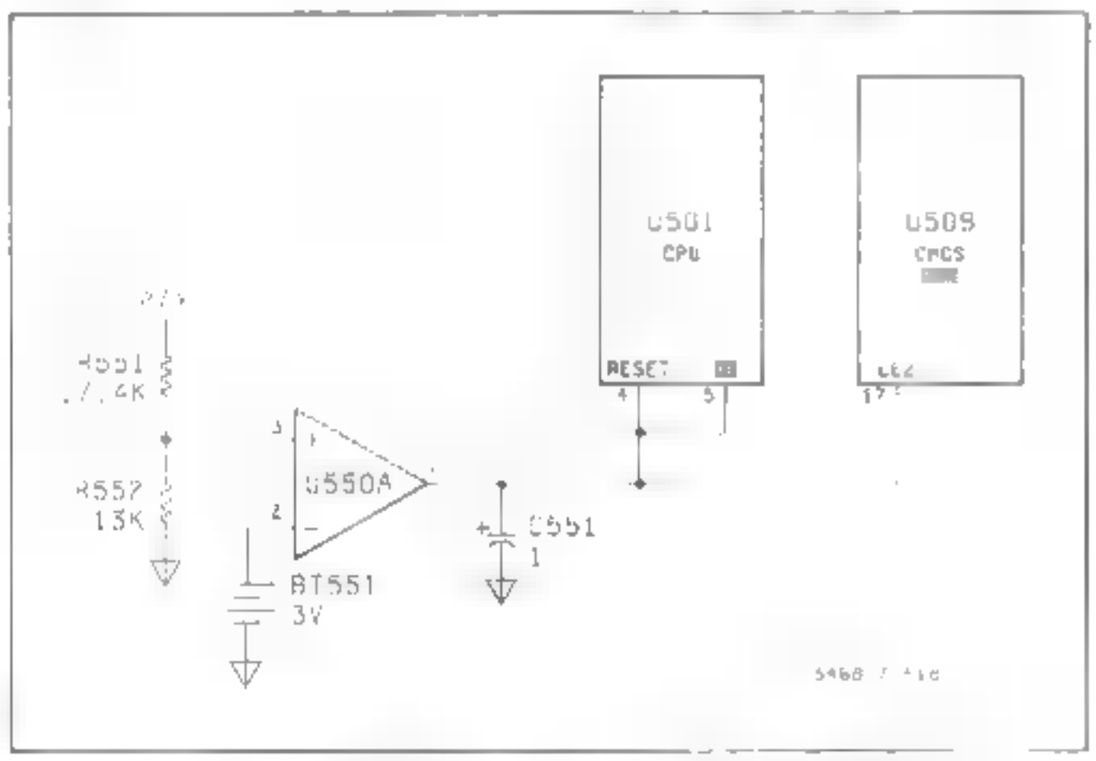


Figure 7-F-18. Power-On Circuitry

1. When the 3468A is turned on, the positive input of comparator U550A goes high after the >7V power supply comes up.

2. Since the negative terminal of U550A is connected to BT551, the output of the comparator attempts to go high and charges capacitor C551. The output goes high since the comparator has an open collector output and a pull-up resistor is connected between the CPU's $\overline{RESET}$ line (output of U550A) and +5V (the resistor is internal to the CPU).

3. During the charge time, the $\overline{RESET}$ line rises from a low level until the capacitor is charged to a high level.

4. The $\overline{RESET}$ line goes high and the CPU resets and turns on. The 3468A is now in its turn-on state.

5. As long as the $\overline{RESET}$ line is low, the CPU's SS (Single Step) line is low (the line is connected to the $\overline{RESET}$ line). Holding the SS line low, forces the $\overline{PSEN}$ line high and prevents the CPU from reading the Control ROM before the ROM is initialized.

6. When the $\overline{RESET}$ line is low, the CE2 line of the CMOS RAM (U509) is also low and disables the RAM (see paragraph 7-F-59).

7. The CPU is also reset when the >7V power supply goes low. A low power supply sets the positive input of U550A low which makes the U550A's output low. This resets the CPU.

b. **Reset Circuitry.** Refer to Figure 7-F-19 or Schematic 3. The Reset Circuitry is used to reset the CPU when the TEST/RESET button is pressed or if the CPU inadvertently goes to a non-operational state. The step by step operation is as follows:

1. During normal operation, counter U504 is continuously incremented by the ALE clock.

2. The counter is reset by the Q1 output of latch U507. The latch receives its data from Port 20. Since the Q1 output of the latch is also connected to the keyboard, the counter is reset as long as the keyboard is scanned (see paragraph 7-F-60). The reset pulse is developed by C503, CR501, and R502.

3. If the TEST/RESET button is pressed or the CPU goes to a non-operational state, the keyboard scanning is stopped.

4. Since the ALE clock is still operating, the counter keeps incrementing for about 1.3 seconds.

5. After the 1.3 seconds, the Q20 output of U504 goes high. This is because the counter is not being reset.

6. The Q20 output is connected to the negative terminal of comparator U550B. Since the positive terminal of U550B is at +3.3V (from the display), U550B's output goes low. This brings the $\overline{RESET}$ line low.

7. The ALE clock continues to increment the counter and after 1.3 seconds the Q20 output goes low.

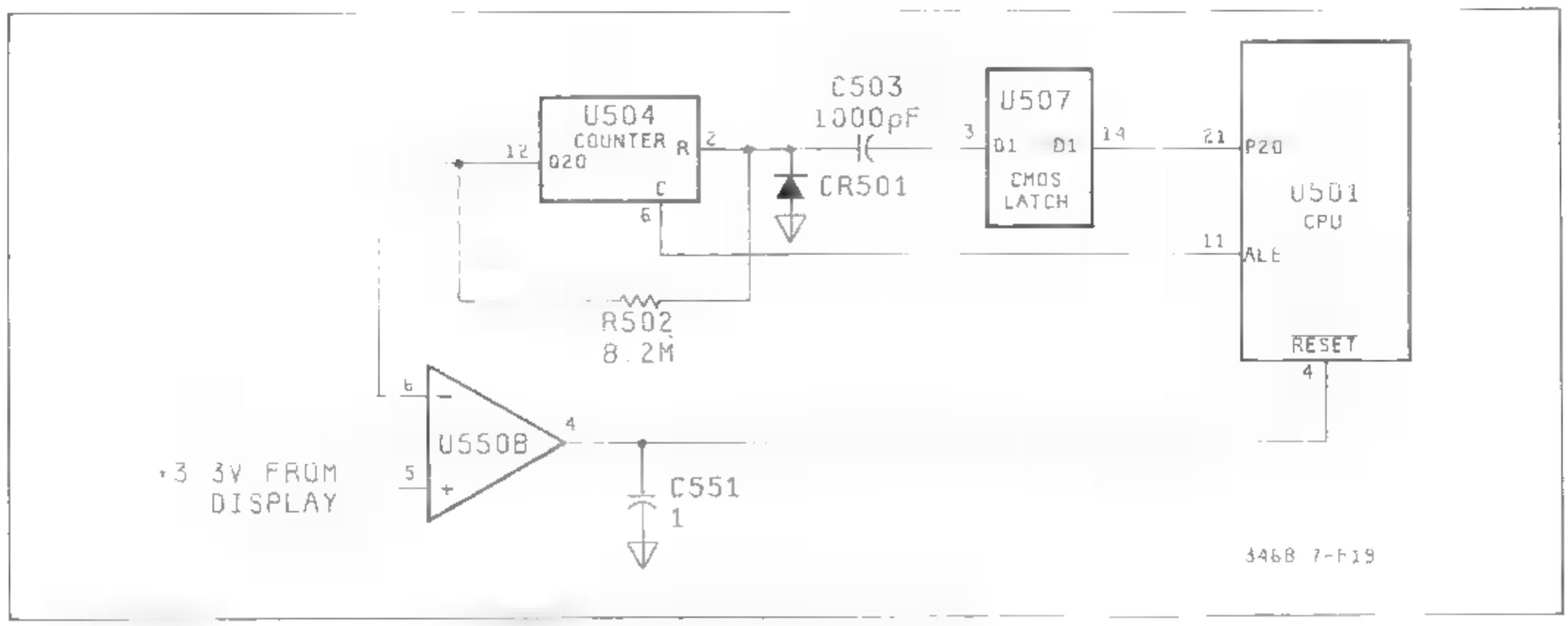


Figure 7-F-19. Reset Circuitry

8. With the Q20 output low, the output of U550B attempts to go high and charges C551 (see step a-2).

9. Once the capacitor is charged to the high level, the CPU then resumes operation. The 3468A is now in its turn-on state.

7-F-55. CMOS RAM. The CMOS RAM is used to store the 3468A'S Calibration Constants. The following paragraphs explain how the RAM is addressed, how data (constants) is read from the RAM, and how new data (new constants) is sent to the RAM. This is done using the RAM's Address, Input, and Output Lines. The Address Lines are connected to the CPU's lower 8 Address bits (A0 to A7). The RAM's input and output lines, (D1 to D4 and DO1 to DO4 respectively, are connected to each other and to the DO to D3 Data Lines.

7-F-56. RAM Addressing. The RAM can only be addressed as long as line CE2 (Chip Enable 2 at U509 pin 17) is high. The line is high when the 3468A is turned on.

7-F-57. Reading the RAM. The RAM can be read under the following conditions.

a. Line OD (Output Disable at U509 pin 18) must be low. It is low when the $\overline{RD}$ Line (Read at U501 pin 8) is low.

b. Line $\overline{CE1}$ must also be low. It receives the low from one section of the CMOS latch U505 (pin 6). The latch transfers data from Port P23 during each ALE cycle.

c. Once the previous conditions are met (the RAM is addressed) and line CE2 is high, data from the RAM is transferred to the Data Lines.

7-F-58. Sending Data to RAM. The RAM can receive new Data when its R/W line (Read/Write at U509 pin 20) is low. This can only happen if the 3468A's Cal Switch (located at the rear panel) is on (down) and the $\overline{WR}$ line of the CPU (Write at U501 pin 10) is low. When the CAL Switch is on (down), it connects the $\overline{WR}$ line of the CPU to the R/W line of the CMOS RAM. When the $\overline{WR}$ line is low, the RAM can then receive new data.

7-F-59. Since the 3468A's Calibration Constants are stored in the CMOS RAM, the constants must remain in the RAM when the 3468A is turned off (or power removed). This is done by battery BT551. In addition, the RAM should not see any possible write commands (R/W low) during the time that power is removed. The RAM must be disabled. This is because a write command may erase some calibration constants. The RAM is disabled by comparator U550A (part of the CPU's power on). The operation is as follows:

a. As long as the 3468A is on, the RAM gets its supply voltage from the +5V power supply through diode CR550.

b. When power is off, the RAM gets its supply voltage from battery BT551 through diode CR551. The battery voltage is used for data retention.

c. After turning power off, the RAM is disabled by setting Line CE2 low. This is done by comparator U550A. The comparator senses a low (or no >7V) from voltage divider R551 and R552. Since U550A's negative terminal is at the battery voltage, the output of U550A discharges C551 before the supply goes off. This makes Line CE2 low and disables the RAM.

7-F-60. Keyboard Operation. The Keyboard's pushbuttons are connected in a 4X4 matrix and are continuously scanned by the CPU. The operation is as follows:

a. One side of the matrix is connected to Ports P10 to P13 of the CPU (U501 pins 27 to 30) and the other side is connected to the Q1 to Q4 outputs of CMOS latch U507 (U507 pins 3 to 6). The latch receives its input from Ports P20 to P23 (U501 pins 21 to 24) and transfers data each time the CPU's PROG line goes low.

b. Before scanning starts, the Q1 to Q4 outputs of U507 and Ports P10 to P13 of U501 are set high. When scanning starts, starting with the Q1 output, each output goes sequentially low.

c. During the time that the keyboard is scanned, the CPU determines which one and if any of Ports P10 to P13 are low. A low on P10 to P13 is used to determine the button pressed. For example, the SRQ button is pressed and turns the corresponding keyboard SRQ switch on. This connects Port P11 to output Q4 which makes P11 low when Q4 is low. Since the CPU knows when it sets Q4 low and also knows when P11 is low, the pressed button is determined.

7-F-61. Display Operation. The 3468A Display is an alphanumeric display with 12 annunciators. The CPU sends serial data to the Display Circuitry which in turn does all the necessary decoding of the data (to display readings, etc.). The operation is as follows:

a. With line PWO high, the CPU can send new data to the Display Circuitry. Data is in serial form and is sent on the INA line (U505 pin 4). For the Display Circuitry to receive and decode the data, the other display lines have to send certain information to the circuitry. This is as follows:

1. The Display Circuitry requires two clock inputs to receive data, $\phi 1$ and $\phi 2$. The inputs come from latch U505 (pin 3) and Port P25 for clock inputs $\phi 1$ and $\phi 2$, respectively.

2. The ISA line (U505 pin 5) is used to give instructions to the Display Circuitry.

3. The SYNC line (U505 pin 6) is used to tell the Display Circuitry when to look for instructions.

b. With line PWO (from Port P24 of the CPU at U501 pin 35) low, the Display Circuitry operates without receiving any data from the CPU. The circuitry can operate in this mode since it has an internal clock (capacitor C501 is the frequency reference). With the circuitry in the internal mode, no updating of the display is done. Line PWO is controlled by the CPU.

7-F-62. HP-IL Operation. All interfacing between the CPU and the Hewlett-Packard Interface Loop (HP-IL) is done by the HP-IL Chip (U503), and isolation transformers T501 and T502. The transformers transfer and receive information between the HP-IL Chip and the HP-IL. The circuitry operates as follows.

a. The HP-IL Chip generates its own clock signal using internal circuitry in conjunction with inductor L501 and C504.

b. When U503 is addressed (by the CPU) and its $\overline{WR}$ (Write) line is low, data from the CPU is sent over the Data Lines to U503. Line $\overline{WR}$ gets its low from the CPU's $\overline{WR}$ line. With the CPU $\overline{WR}$ line low, its $\overline{RD}$ (Read) line is high (which makes U503's $\overline{RD}$ line high). Depending on the Register selected (RS0 to RS2 at U503 pins 5 to 3, which are the A0 to A2 Address Lines of the CPU), U503 interprets the data as the interface state (Talker, Listener, etc.) or a frame of data to be sent.

c. When U503 is addressed (by the CPU) and its $\overline{RD}$ line is low, U503 is enabled to send data to the CPU over the Data Lines. Line $\overline{RD}$ gets its low from the CPU's $\overline{RD}$ line. Depending on the Register selected (RS0 to RS2, see previous step), the data may be a frame which was received or status about the state of the interface.

d. The CPU continuously checks (for HP-IL data) and updates U503.

e. Capacitors C508 and C509 in conjunction with resistors R505 and R506 are used as filters (for the transmitter). Resistors R503 and R504 are used as pull-down resistors (for the receiver). Diodes CR552 through CR555 are used as overvoltage protection for the HP-IL Chip.

7-F-63. Rear Panel Switch. The Rear Panel Switch (S501) is an eight section DIP switch used to select the 3468A's Signature Analysis (SA) Routines, set the Power SRQ Status Bit, set the 3468A to the talk-only mode, set the multimeter to the selected power line frequency, and to enable calibration. Except for the calibration operation (it is explained in Section IV of this manual), the purpose and operation of the switches is as follows:

a. **SA1 and SA2.** The 3468A has two SA routines, SA1 and SA2, which are selected by switch S501. Switch SA1 is used to hold address line A12 of the ROM low. At power on reset, this places the CPU and ROM to the SA1 code location. Switch SA2 is used to hold the CPU's INT (interupt) line low. At power on reset, this will signal the CPU to go to the SA2 routines.

b. **Power-On SRQ.** This switch holds the A6 line of the HP-IL Chip low. This line determines the value of bit 7 of the SRQ Mask (see this manual's Section III for information on the Power SRQ Bit).

c. **Talk-Only Mode.** In this case, the switch holds the HP-IL Chip's A7 line low and the 3468A is placed into the talk-only mode by the chip (refer to this manual's Section III for information on this mode).

d. **Power Line Frequency (50Hz/60Hz).** This switch holds the T0 input line (U501 pin 1) of the CPU low. The CPU will then select the A/D Converter's Integration Time for the selected power line frequency (1/60 second for 60Hz or 1/50 second for 50Hz, etc.).

7-F-64. A/D Converter Control. The A/D Converter receives control data from the CPU's Ports P15 to P17 (U501 pins 32 to 34), P26 (pin 37), and P27 (pin 38). The data is used to select the various slopes (see paragraph 7-F-49 step a) in the converter. The output of the A/D Converter (CMP, the Comparator Output) is applied to the T1 input of the CPU (at U501 pin 39). The ALE output is used as the A/D converter's clock. Refer to paragraph 7-F-31 for more information on the A/D operation.

7-F-65. Input Hybrid Control. The control lines to the Input Hybrid (U102) are: Data, Mode, and Clock. The Data line comes from the Q3 output of latch U505 (pin 5), the Mode line comes from Port P10 (U501 pin 27), and the Clock comes from Port P26 (U501 pin 37). The lines do the following.

a. When the Clock input (U102 pin 24) is low, no data is transferred into the hybrid.

b. When the clock input makes a transition from low to high, the following happens:

1. When the Mode input (U102 pin 25) is low, data on the Data line (U102 pin 26) is transferred into the hybrid (into an internal shift register).

2. When the Mode input is high, the data in the hybrid (in its shift register) is used to set-up the switches in the hybrid.

7-F-66. Digital to Analog Converter Operation. The 3468A's A/D Converter requires a certain offset voltage (see paragraph 7-F-46 for more information). This offset is applied to the negative input of the A/D Integrator (U401) and comes from the Digital to Analog Converter (DAC). The offset voltages are developed by resistors R401 to R406, which are selected by CMOS latches U505 and U507. Each time latch U505 is clocked by the ALE and latch U507 is clocked by the CPU's PROG line, the output of the latches is either high or low. This depends on the position (high or low) of Ports P20 to P23. The outputs in conjunction with resistors R401 to R406 then generate a certain offset voltage.

7-F-67. Power Supplies

7-F-68. General. The 3468A has three power supplies: +15V, -15V, and +5V (plus an unregulated supply, >7V). All power supplies use transformer T730 as the main power source. If the 3468A has the battery option (Option 001), the Battery Charger Circuitry (see Paragraph 7-F-72) supplies the raw voltages for the power supplies when ac power is removed. Refer to Schematic 4 for the following explanation on the power supply circuitry.

7-F-69. +5V and >7V Supplies. A full-wave rectifier, consisting of CR703 and CR704, develop the raw (unregulated) voltage for the +5V power supply. The voltage is the >7V supply and comes from the Battery Charger when ac power is removed. The +5V regulated voltage is developed by voltage regulator U701. Breakdown diode CR712 is used for overvoltage protection. Capacitor C705 and C731 are filter capacitors. Diode CR707 normally does not conduct, but will conduct if the +15V power supply goes below +5V. This is used to protect the Input Hybrid, U102, if the +15V supply goes low. Temperature sensitive resistor RT705 is used to protect supplies from excessive output currents. The protection circuitry operates as follows:

a. If the output current of the +5V and >7V is excessive, RT705 heats up.

b. Since RT705 has a positive temperature coefficient, its resistance increases to a large value due to high temperature.

c. The high resistance causes most of the supply voltage to drop across RT705, in effect shutting down the supplies.

d. The large resistance value remains until RT705 cools down (power supply draws normal current).

7-F-70. +15V Supply. A voltage doubler circuit, consisting of C741, C703, CR701, and CR702, is used to develop the raw (unregulated) voltage for the +15V supply. The voltage comes from the Battery Charger when ac power is removed. The voltage doubler circuit develops the raw voltage by charging capacitor C741 during the negative cycle of the ac power source (T730). The capacitor is charged through diode CR702 (CR701 does not conduct at this time). During the positive ac cycle, CR701 conducts and rectifies the ac voltage to dc. The resultant dc voltage is the positive voltage from the secondary of the power transformer (between pins 11 and 13 of T730) plus the charge on capacitor C741. This makes the resultant voltage approximately twice the peak ac voltage (+20V). Diode CR752 prevents any negative voltages from being applied to the positive side of C741 (which may happen at turn on). The regulated +15V comes from voltage regulator U703. Breakdown diode CR750 and CR711 are used for overvoltage protection. Capacitor C704 is a filter capacitor. Temperature sensitive resistor RT707 is to protect the supply from excessive output currents (see Paragraph 7-F-69 step a).

7-F-71. -15V Supply. The -15V Supply is a mirror image of the +15V Supply. Refer to the explanation of the +15V Supply (see previous paragraph) for the explanation on the -15V Supply. Keep in mind that the currents and voltages are opposite in polarity.

7-F-72. Battery Charger Circuitry (Option 001)

7-F-73. The Battery Charger Circuitry is located on the A3 assembly and does the following:

a. **Battery Charging (Power Switch Off).** The Battery is charged (if it needs charging) with a typical charge current of 400mA.

b. **Battery Charging (Power Switch On).** The Battery is charged (if it needs charging) with a typical current of 130mA.

c. **Battery Only Operation.** The battery supplies the power for the DC to DC Converter which supplies the raw (unregulated) voltages for the 3468A's +5V, +15V, and -15V power supplies.

7-F-74. The Battery Charger Circuitry consists of a Battery, Battery Charger, Voltage and Current Sensing Circuitry, and a DC to DC Converter. The following paragraphs explain how the different circuitry operates. Refer to Schematic 5 (and 4) for the explanation.

7-F-75. Battery Charging (Power Switch Off). With the power switch off and ac power applied to the 3468A, the Battery Charger operation is explained in the following steps. Refer to Figure 7-F-20 (Simplified Schematic Of The Battery Charger) for the explanation.

a. The output from transformer T730 (coming through pins 8 and 16 of P701) is connected to full-wave rectifier CR901 and CR902. The dc output of the diodes is used as the battery charger power supply when ac power is connected to the 3468A.

b. Comparator U902A (in conjunction with Q901 and Q902) determines if battery BT901 needs charging. Comparator U902A in conjunction with U902B also determines the maximum allowable charge current. The operation is as follows:

1. If the battery voltage is less than approximately 7.1V (the voltage decreases as temperature increases), the battery needs to be charged.

2. The battery voltage is divided down by divider R924, R904, R903, and RT922. The resultant voltage drop across R903 is applied to the negative terminal of U902A.

3. The positive terminal of U902A is at +2.5V, which comes from voltage regulator U901. If the negative terminal of U902A is below +2.5V, its output goes high. This is because the comparator operates as an amplifier. The high output turns Q902 on harder which turns Q901 on harder, supplying more current to the battery.

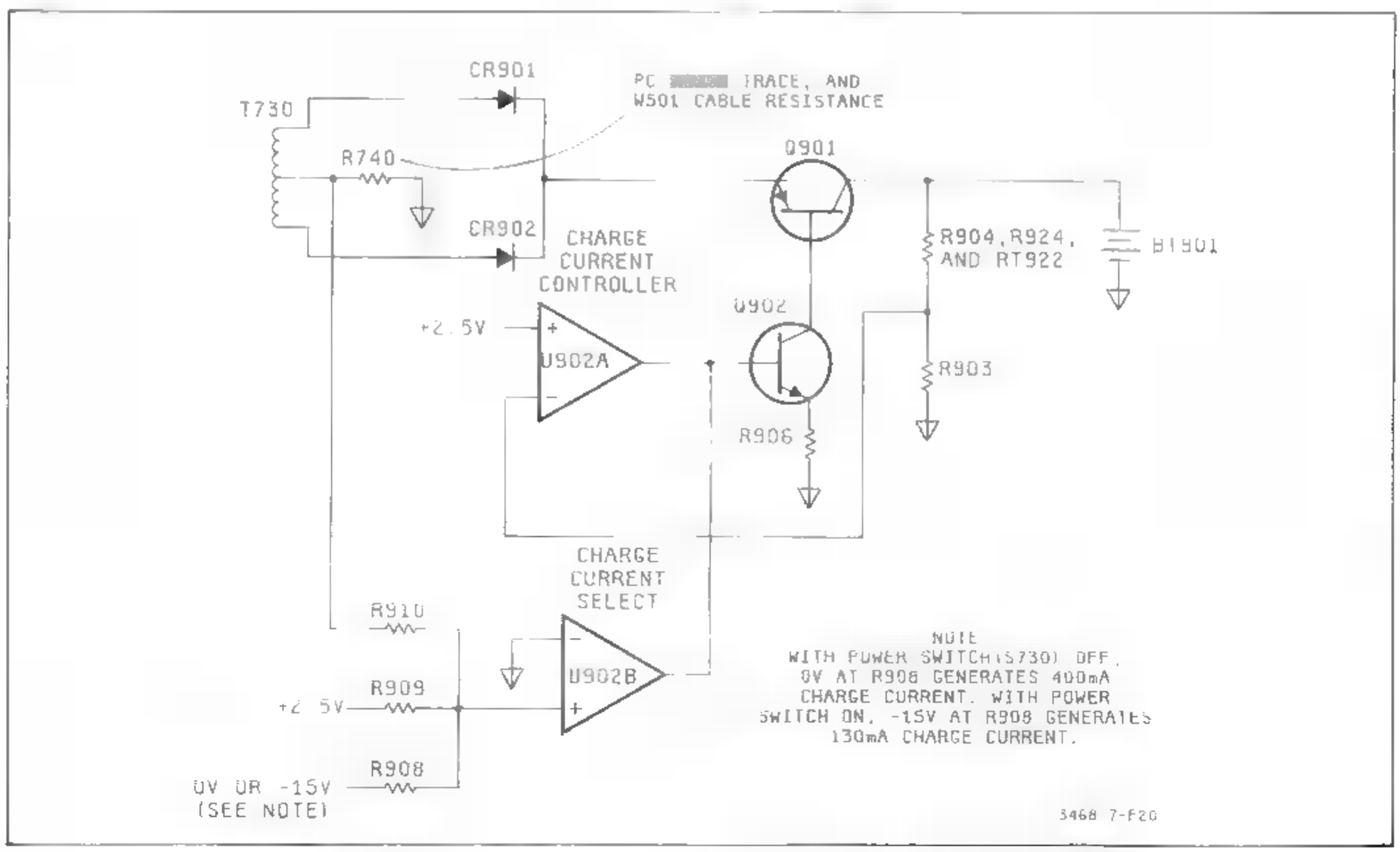


Figure 7-F-20. Simplified Schematic Of The Battery Charger

4. If the positive terminal of U901A goes above +2.5V, its output goes lower and turns Q901 and Q902 on less hard (the battery receives a smaller charge current). When the battery is completely charged, there is still a trickle charge current of approximately 5mA. The current prevents the battery from discharging itself and to maintain the battery voltage at approximately 7.1V.

5. Diode CR904 is used to supply the power for U902 when ac power is connected to the 3468A and CR905 is used to supply the power (from the DC to DC Converter) when ac power is disconnected. Diode CR905 has to supply power to U902 since U902 is also used when power is disconnected.

c. Comparator U902B is used to determine the maximum battery charge current and operates in conjunction with U902A. The operation is as follows:

1. The negative terminal of U902B is connected to ground.

2. The positive terminal of U902B is connected to summing resistors R908, R909, and R910. Resistors R908, R909, and R910 are connected to the -15V power supply, to +2.5V, and to R740 (at the center tap of T730), respectively. The voltage drop across R740 is directly proportional to the sum of the battery charge current and the +5V supply current.

3. With the 3468A's power switch off, the -15V supply is at zero volts and the +5V power supply current is zero. At this time, the voltage drop across R740 depends on only the current drawn by the battery charge circuitry. Since the negative terminal of U902B is at zero volts (ground potential), the positive terminal must also be at zero volts (for normal operation). This is true when the voltage drop across R740 is at a certain value. The voltage drop has the correct value when the battery charge current is approximately 400mA. Comparator U902B in effect forces its positive terminal to zero volts by controlling the amount of battery charge current (using Q901 and Q902).

4. With the 3468A's power switch on, the -15V and +5V power supplies are now on. At this time, the voltage drop across R740 depends on the current drawn by the battery charge circuitry and the +5V supply. In order for the positive terminal of U902B to be at zero volts, the voltage drop across R740 must now be different (because the -15V and +5V power supplies are now on). The voltage drop across R740 is now correct when the battery charge current is at approximately 130mA.

7-F-76. **Battery Only Operation.** In this mode, the DC to DC Converter generates the raw power supply voltages for the 3468A's power supplies. Three conditions must be met for the converter to operate: the ac power source is disconnected from the multimeter, the instrument is on (power switch on), and the battery voltage must be high enough. The following steps explain the operation of the DC to DC Converter. Refer to Figure 7-F-21 (simplified schematic of the DC to DC Converter) for the explanation.

a. When power is disconnected from the 3468A, the condition is sensed by comparator U902D and turns the DC to DC Converter on.

1. As long as ac power is applied to the 3468A, the positive terminal (pin 7) of U902D is at a level larger than +2.5V. The voltage at U902D pin 7 comes from one of the ac lines of T730 (P701 pin 16), after the ac voltage is rectified by CR903 and divided down by divider R901 and R902. Under normal conditions, the voltage must be above +2.5V, since the negative terminal of U902D is at +2.5V. This makes the output of U902D high and prevents the DC to DC Converter from operating.

2. When ac power is disconnected, the positive terminal of U902D goes to zero. The result is that the output of comparator U902D, which is connected to one input of Nor gate U903B, goes low.

3. The other input of U903B is also low because the SR flip-flop (U903C and U903D) is set (U903D pin 11 is low). The flip-flop is used to make sure the battery voltage is large enough for the DC to DC Converter to operate. The flip-flop is set by two different methods. The first method is a positive pulse which is generated from the battery voltage (which comes through the power switch and P701 pin 9). The pulse is developed through C904 and across R914 and is applied to one input of nor gate U903A, and also to the S (set) input of the flip-flop. In the second method, U902D (when the line voltage is high), will do the same as a positive pulse. Since the other input of U903A is also high, if the battery voltage is high enough, its output is low and the flip-flop is set. The RC time constant of C904 and R914 assures enough time for the power supply (from the DC to DC Converter) to stabilize the circuitry.

4. With both inputs to U903B low, its output is high and resets (turns on) CMOS timer U905.

5. The CMOS timer generates a rectangular waveform (at approximately 28KHz) which is inverted by gate U904A (U904A is a Nor gate connected as an inverter). The frequency of the timer is determined by R915, R916, CR911, and C911.

6. When the output of U904A is low, the outputs of Nor gates U904B, C, and D (which are also connected as inverters) are high. The high turns on transistor Q905 which turns on transistor Q904. Current then flows from the battery into transformer T901.

7. When the output of U904A is high, the outputs of U904B, C, and D go low and turn Q904 and Q905 off. This turns the current flow through T901 off. A high output of U904A also turns on Q903. This is used to turn Q904 off quicker.

8. With Q904 on and current flow to T901 increasing, the magnetic field of T901 expands and voltage is induced into its secondary. With Q904 off and current flow to T901 disabled, the magnetic field of T901 collapses and voltage of opposite polarity is induced into its secondary. These voltages are rectified by bridge rectifier CR912, CR913, CR914, and CR915 and also by bridge rectifier CR916, CR917, CR918, and CR919. The resultant dc voltages are the raw voltages for the 3468A's power supplies.

b. When the battery voltage is low (less than approximately +5.5V), the DC to DC Converter turns off. The operation is as follows:

1. The battery voltage divided down by voltage divider R911 and R912 and applied to the positive terminal of comparator U902C. The terminal is normally above +2.5V and makes the output of U902C high.

2. The negative terminal of U902C is at +2.5V. When the positive terminal goes below 2.5V (battery voltage low), the output of U902C goes low. This in turn makes the output of Nor gate U903A low.

3. The flip-flop then changes state (output high) which generates a low output from Nor gate U903B (with pin 5 of U903B high and pin 6 low, the output is low).

4. The low output of U903B turns the CMOS timer (U905) off. This in turn disables the DC to DC Converter. The 3468A then becomes inoperative (battery needs to be charged).

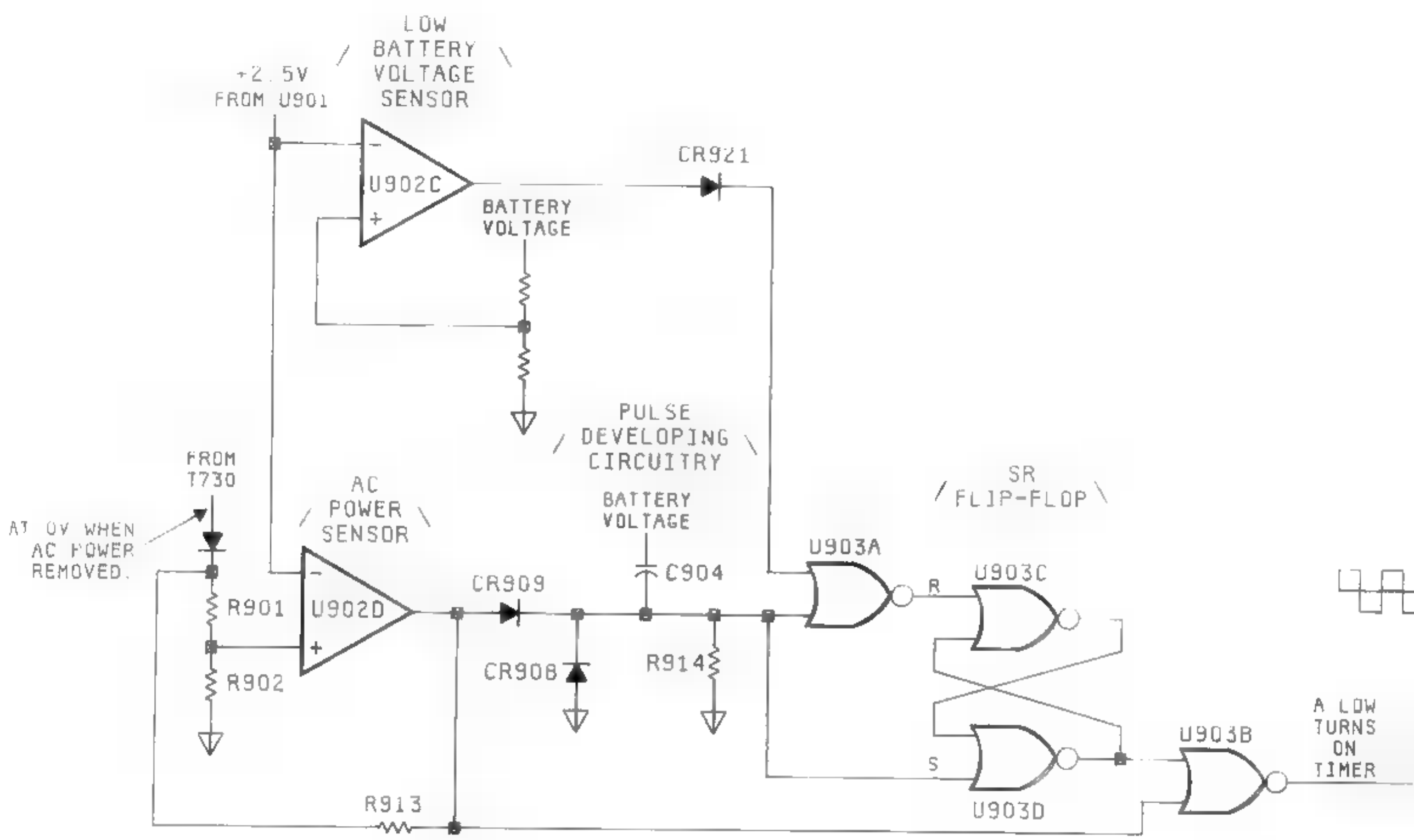
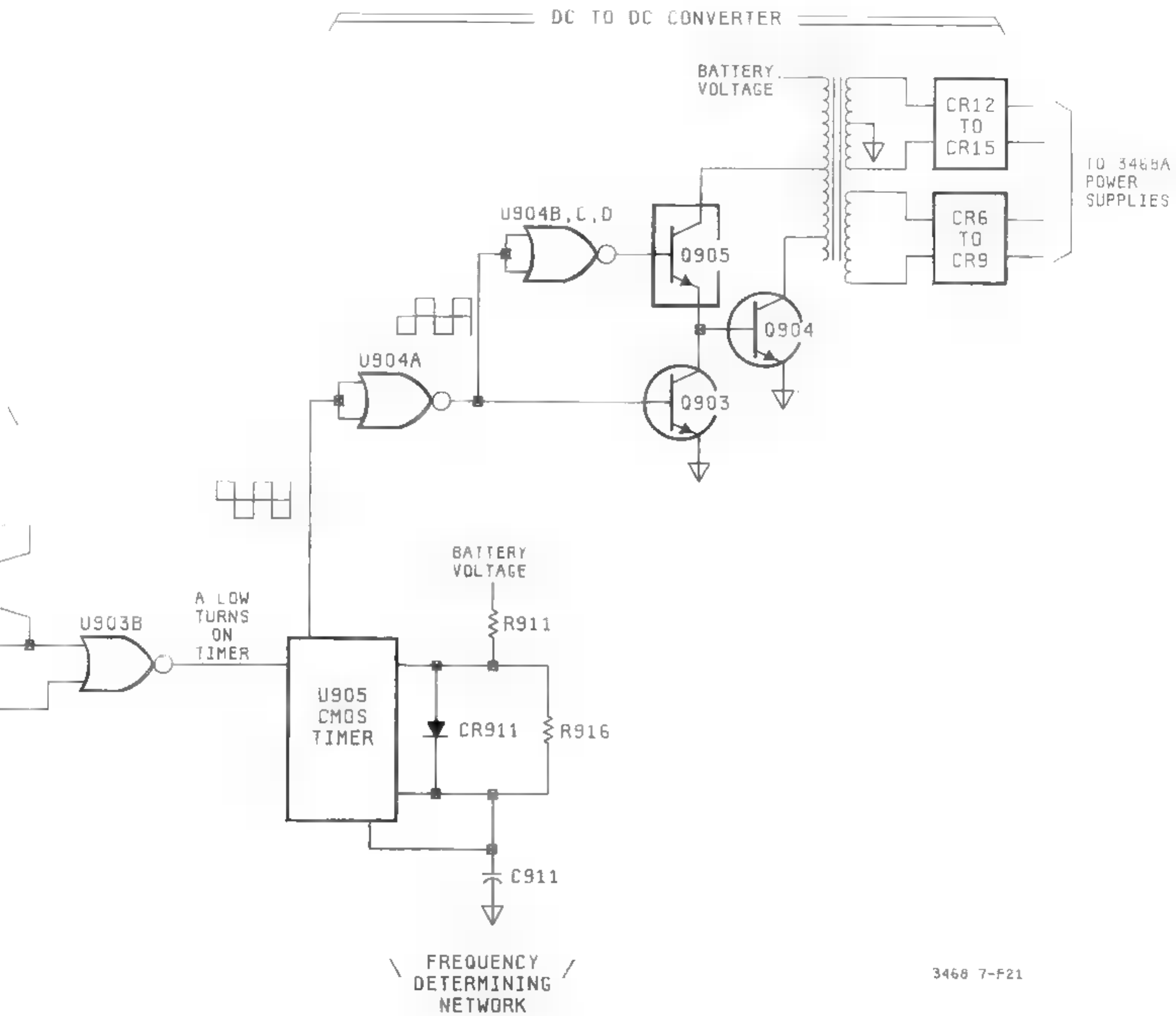


Figure 7-F-21. Simplified Schematic ■ The



21. Simplified Schematic Of The DC to DC Converter

SERVICE GROUP G
SCHEMATICS

Service Group G Contents

Title	Figure
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AC to DC Converter (Schematic 2)	7-G-4
A/D Converter and Control Logic (Schematic 3)	7-G-5
Power Supplies (Schematic 4)	7-G-6
Battery Charger (Schematic 5)	7-G-7

7-G-1. INTRODUCTION

7-G-2. This Service Group has the 3468A's Block Diagram and Schematics. In addition, general schematics notes are also included to gain an understanding on how to use the schematics.

GENERAL SCHEMATIC NOTES

1. RESISTANCE IN OHMS, CAPACITANCE IN MICROFARADS, INDUCTANCE IN MICROHENRIES UNLESS OTHERWISE NOTED.
2. ASTERISK DENOTES A FACTORY-SELECTED VALUE. VALUE SHOWN ON SCHEMATIC IS TYPICAL.
3. ENCLOSES FRONT PANEL MARKING.
4. ENCLOSES REAR PANEL MARKING.
5. CIRCUIT ASSEMBLY BORDERLINE.
6. OTHER ASSEMBLY BORDERLINE. ALSO USED TO INDICATE MECHANICAL INTERCONNECTIONS (GANGING).
7. \918/ DENOTES WIRE COLOR CODE. CODE USED IS SAME AS THE RESISTOR COLOR CODE. FIRST NUMBER IDENTIFIES THE BASE COLOR, SECOND NUMBER IDENTIFIES THE WIDER STRIPE, THIRD NUMBER IDENTIFIES THE NARROWER STRIPE.

   E.G. \918/ DENOTES WHITE BASE, BROWN WIDE STRIPE, GRAY NARROW STRIPE.
8. DENOTES GROUND ON PC ASSEMBLIES.

Figure 7-G-1. General Schematic

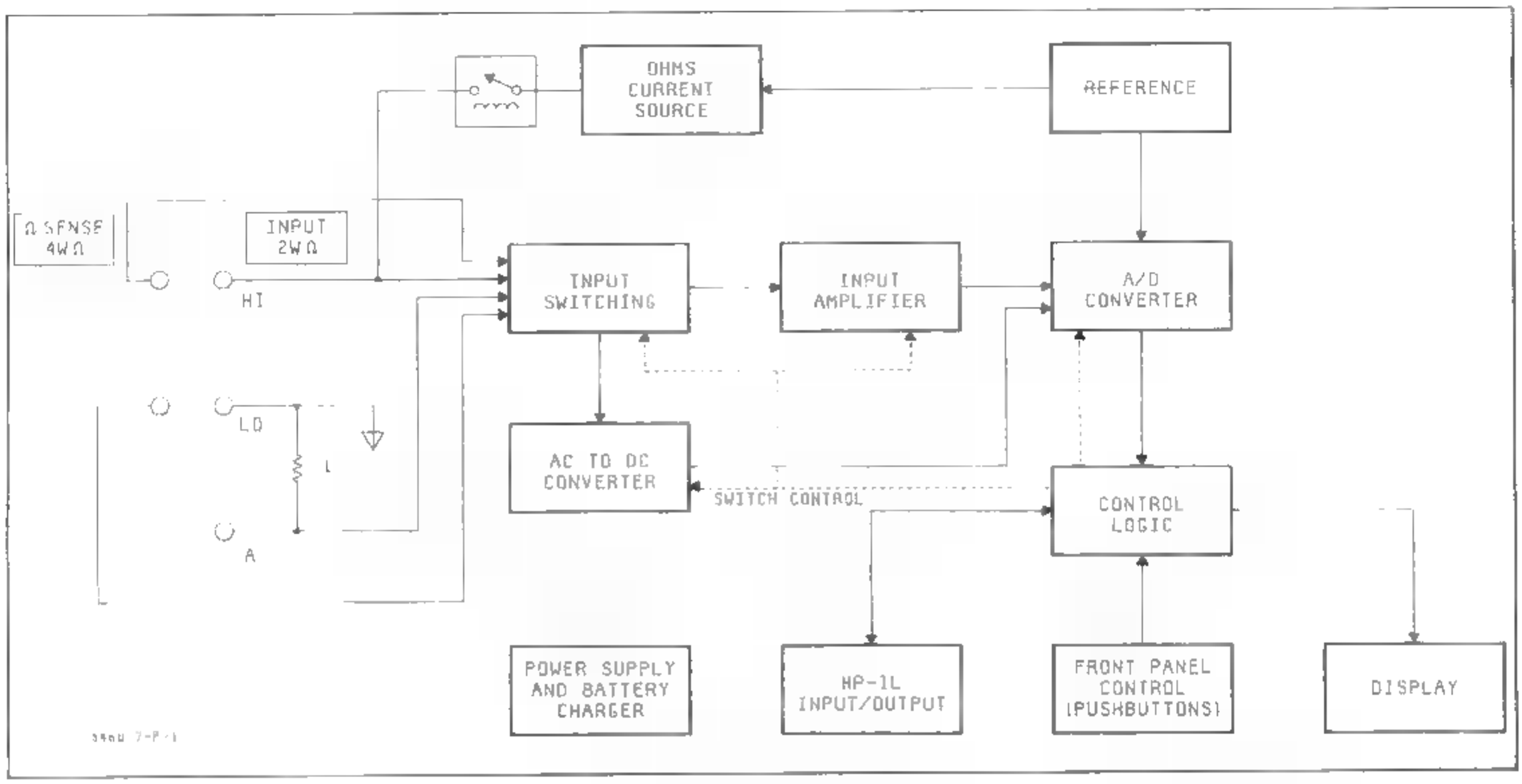
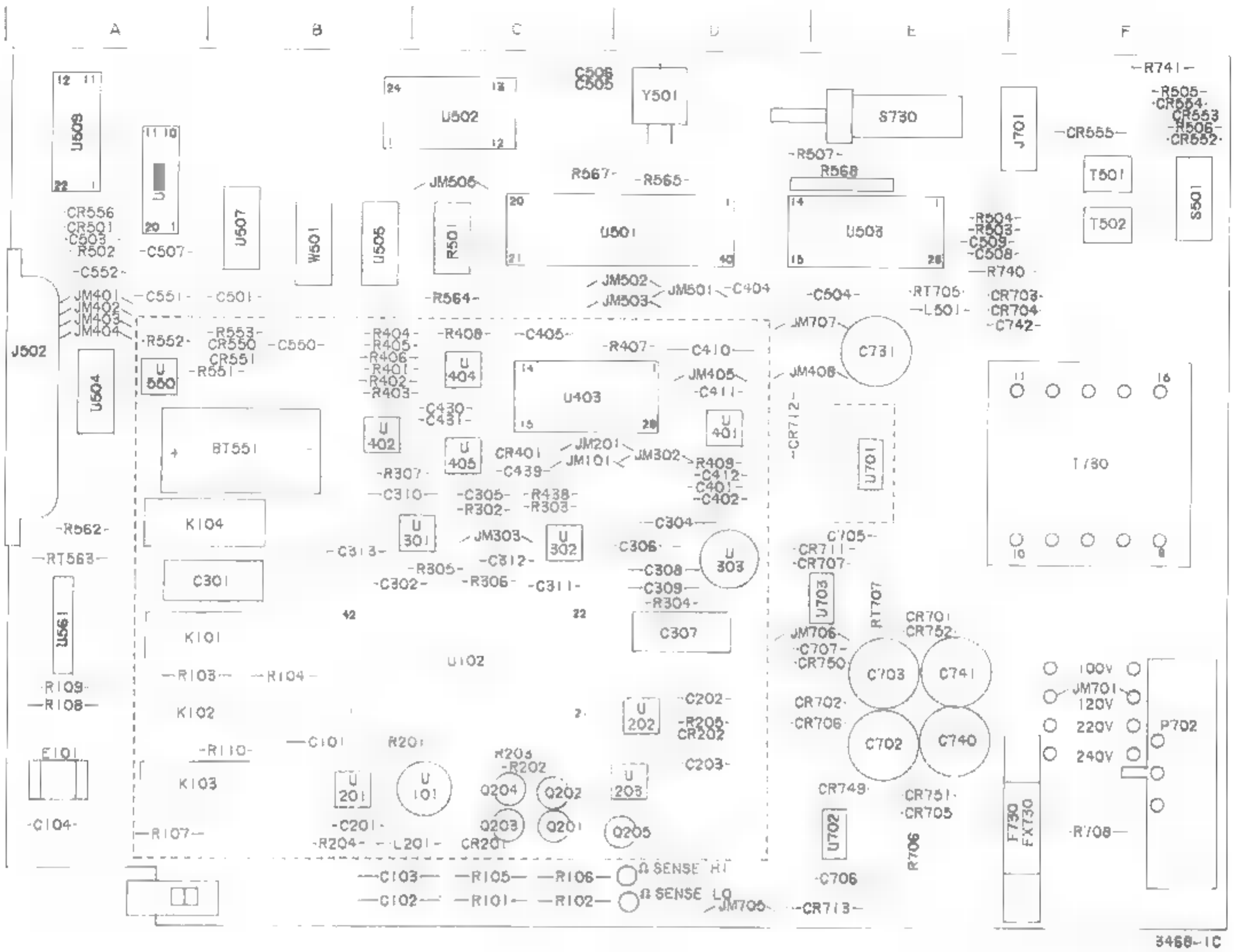


Figure 7-G-2. 3468A Block Diagram



A1

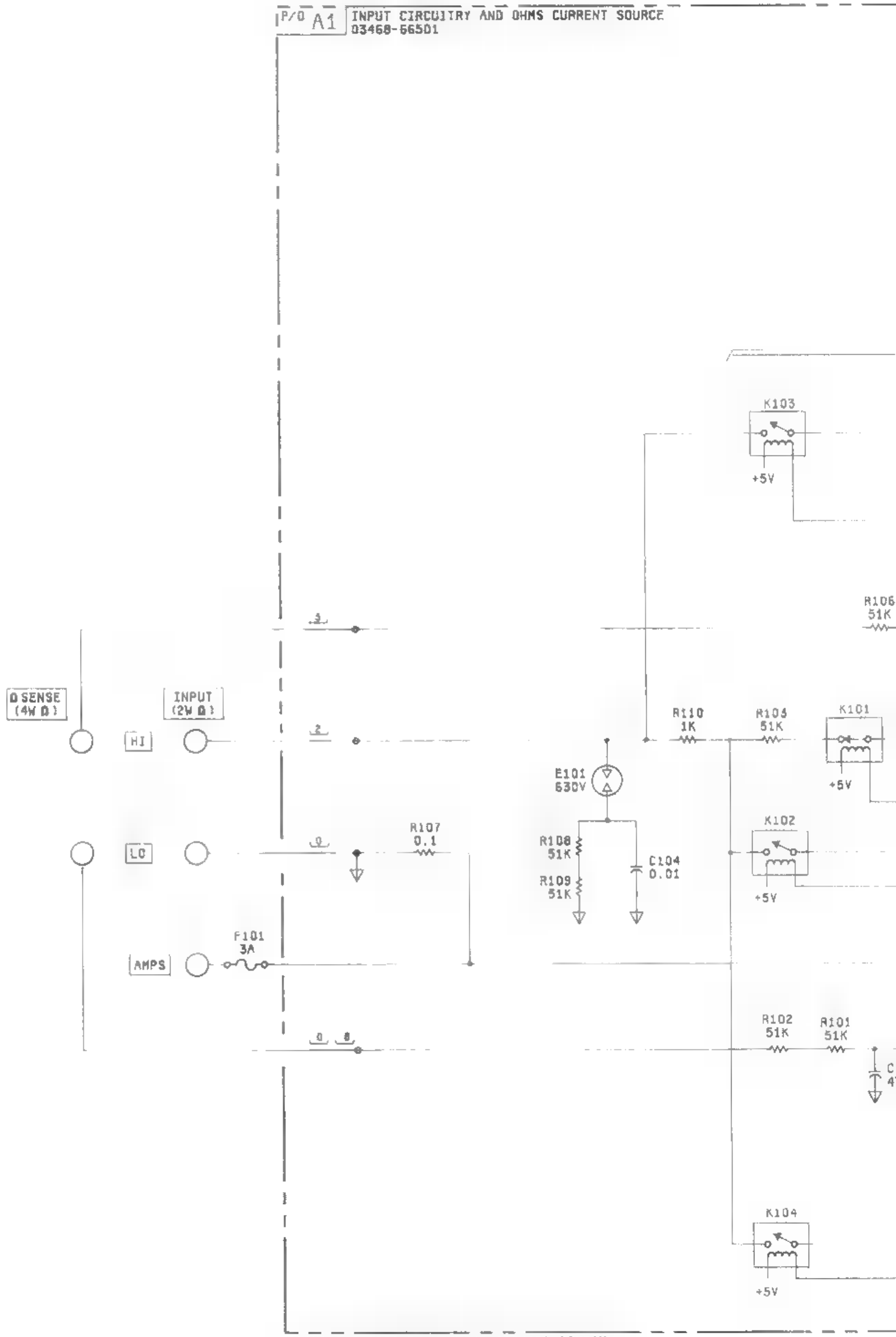
-hp- Part Number 03468-66501

Component	Col.
C101	B
C102	B,C
C103	B,C
C104	A
C201	B
C202	D
C203	D
C301	A,B
CR201	C
CR202	D
E101	A

Component	Col.
JM101	C
JM102	C
K101	A,B
K102	A,B
K103	A,B
K104	A,B
L201	B,C
Q201	C
Q202	C
Q203	C

Component	Col.
Q204	C
Q205	D
R101	C
R102	C
R103	A,B
R104	■
R105	C
R106	C
R107	A
R108	A
R109	A
R110	A,B

Component	Col.
R201	C
R202	C
R203	C
R204	B
R205	D
U101	B,C
U102	B,C
U201	B
U202	D
U203	C,D



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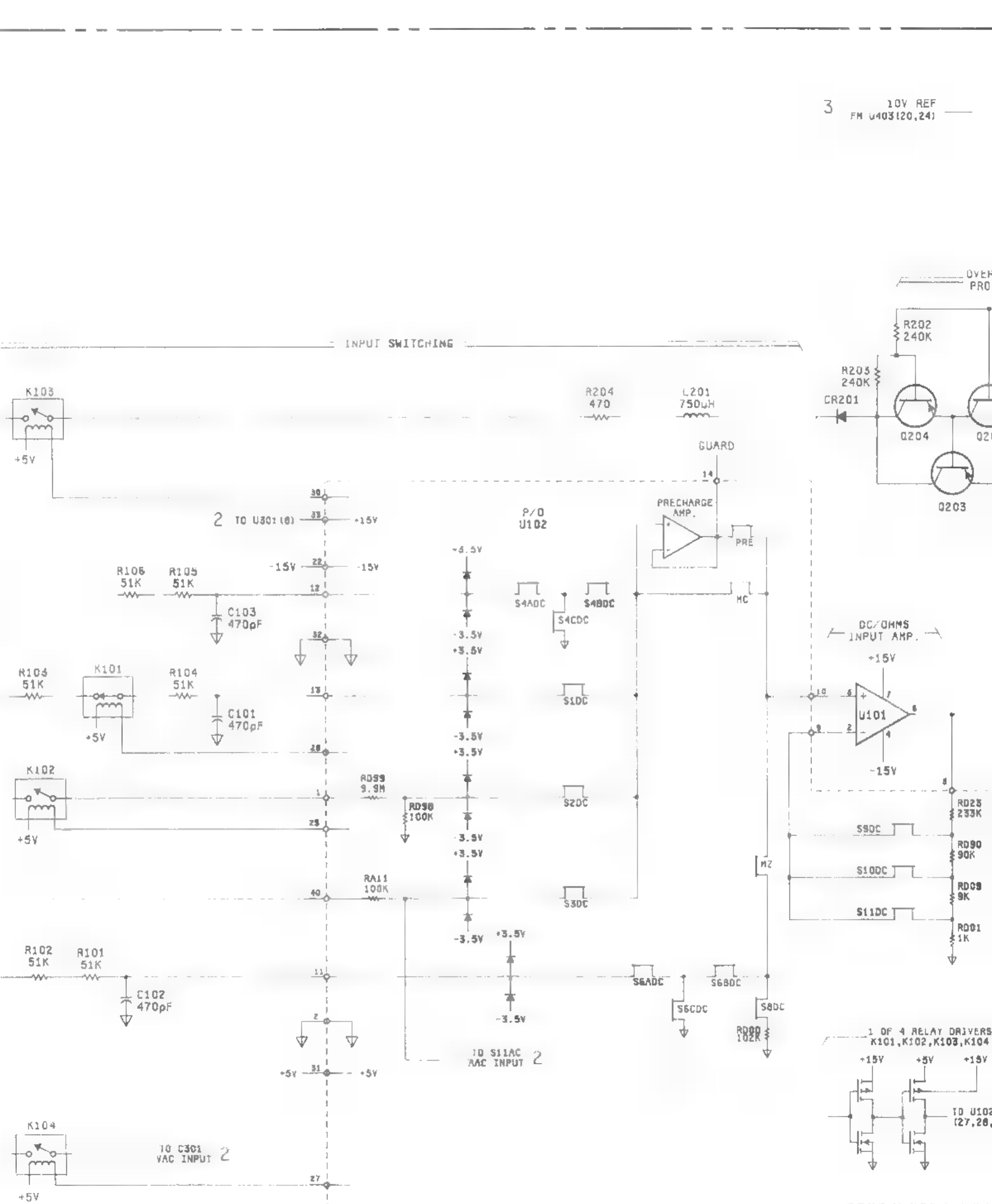
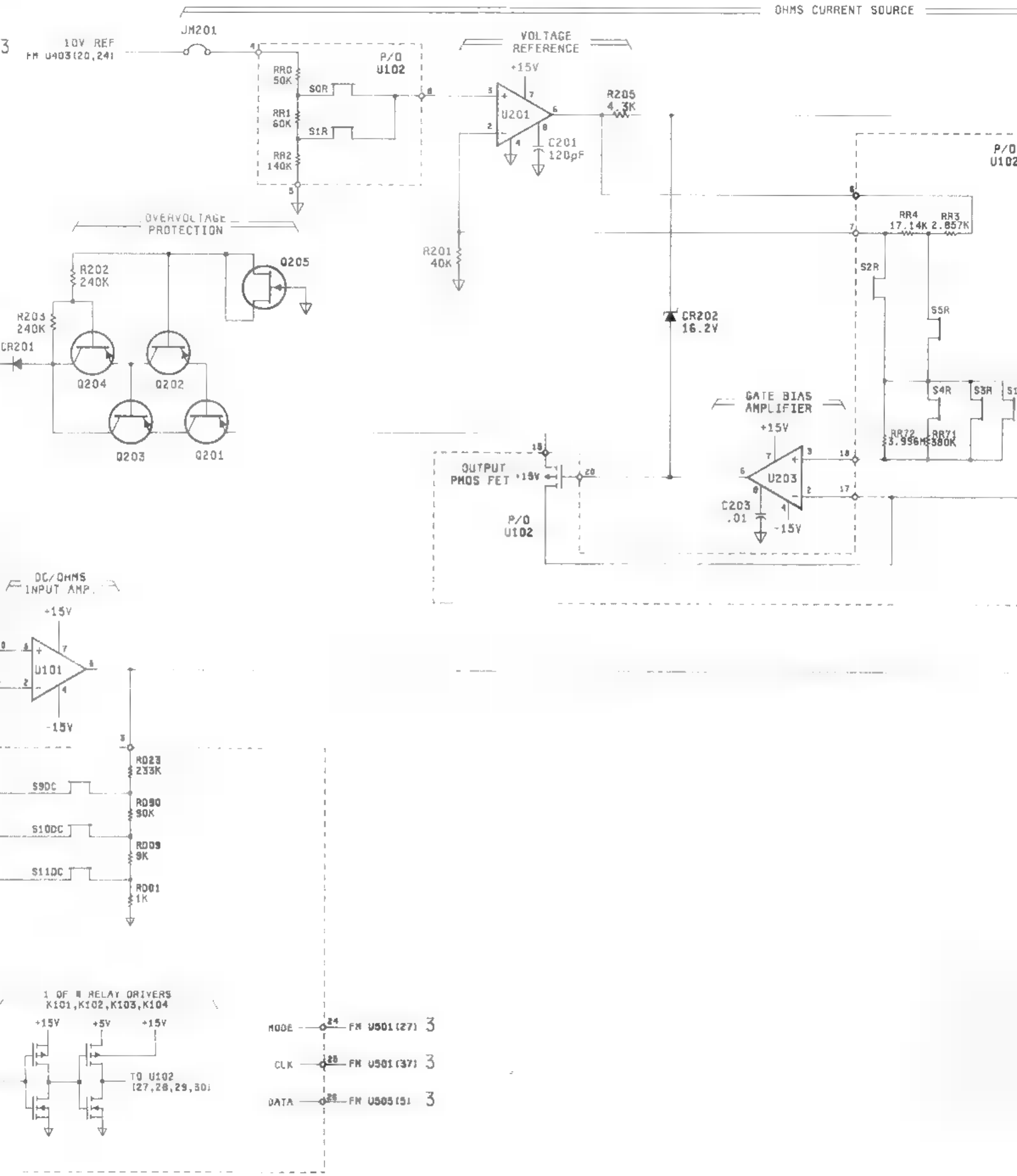

INPUT SWITCHING
10V REF
FM U403(20,24)
OVER
PRO
R202
240K
R203
240K
CR201
Q204
Q203
K103
+5V
R204
470
L201
750uH
GUARD
PRECHARGE
AMP.
PRE
P/O
U102
TO U301(8)
+15V
-15V
R106
51K
R105
51K
C103
470pF
S4ADC
S4BDC
S4CDC
MC
DC/OHMS
INPUT AMP.
R103
51K
K101
R104
51K
C101
470pF
S1DC
U101
K102
RD99
9.9M
RD98
100K
S2DC
RD25
233K
S9DC
RD90
90K
S10DC
RD09
9K
S11DC
RD01
1K
RA11
100K
S3DC
MZ
R102
51K
R101
51K
C102
470pF
S6ADC
S6BDC
S6CDC
S8DC
RD00
102K
TO S11AC
VAC INPUT
1 OF 4 RELAY DRIVERS
K101,K102,K103,K104
TO U102
(27,28,
K104
TO C301
VAC INPUT


OHMS CURRENT SOURCE
JM201
10V REF
FM U403(20,24)
P/O
U102
RR0
50K
SOR
RR1
60K
S1R
RR2
140K
VOLTAGE
REFERENCE
+15V
U201
R205
4.3K
C201
120pF
R201
40K
OVERVOLTAGE
PROTECTION
R202
240K
Q205
R203
240K
CR201
Q204
Q202
Q203
Q201
CR202
16.2V
RR4
17.14K
RR3
2.857K
S2R
S5R
S4R
S3R
RR72
3.956M
RR71
380K
GATE BIAS
AMPLIFIER
+15V
U203
C203
.01
-15V
OUTPUT
PMOS FET
+15V
P/O
U102
DC/OHMS
INPUT AMP.
+15V
U101
-15V
RD23
233K
S9DC
RD90
90K
S10DC
RD09
9K
S11DC
RD01
1K
1 OF 8 RELAY DRIVERS
K101,K102,K103,K104
+15V
+5V
+15V
TO U102
(27,28,29,30)
MODE
FM U501(27)
CLK
FM U501(37)
DATA
FM U505(5)

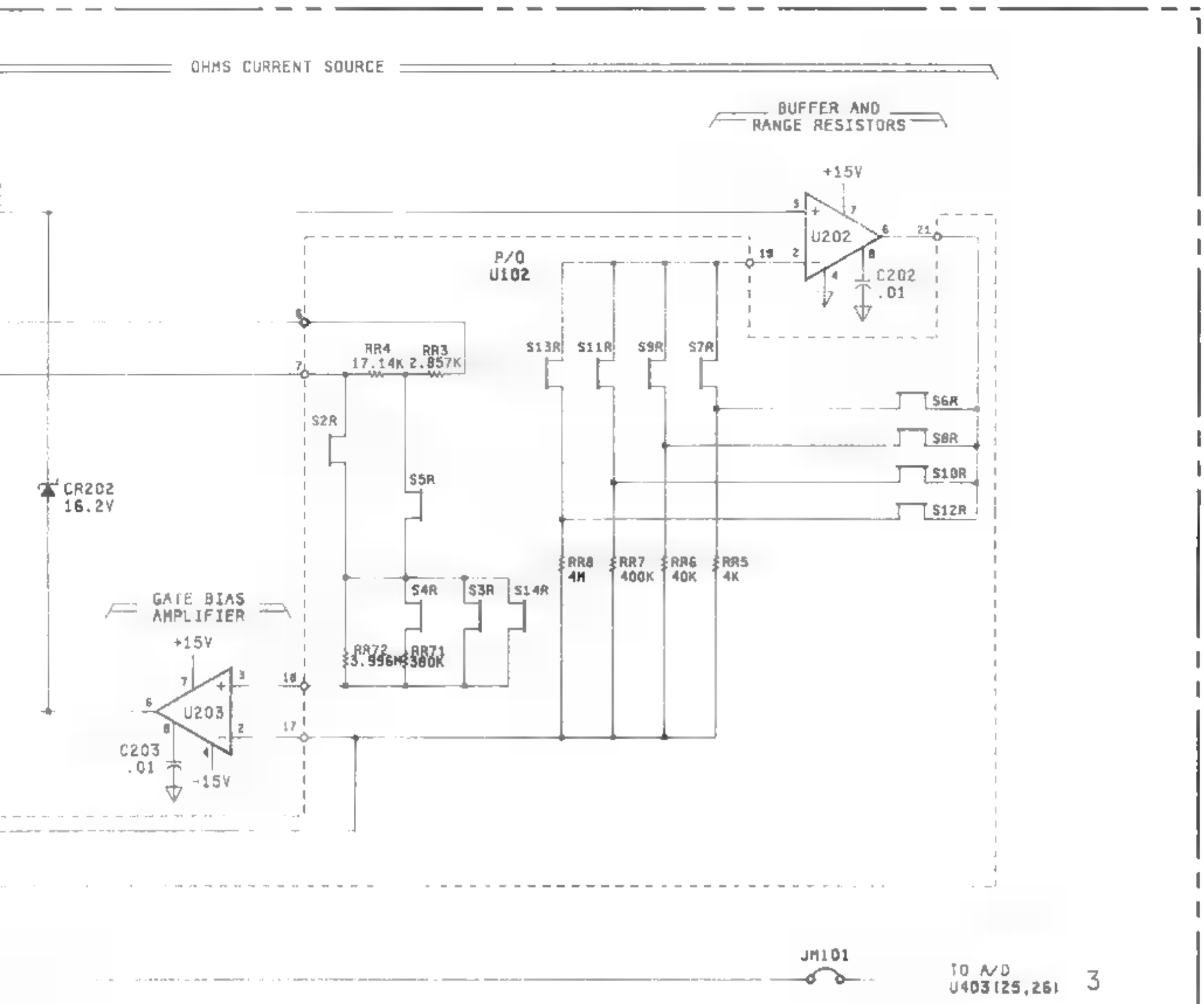
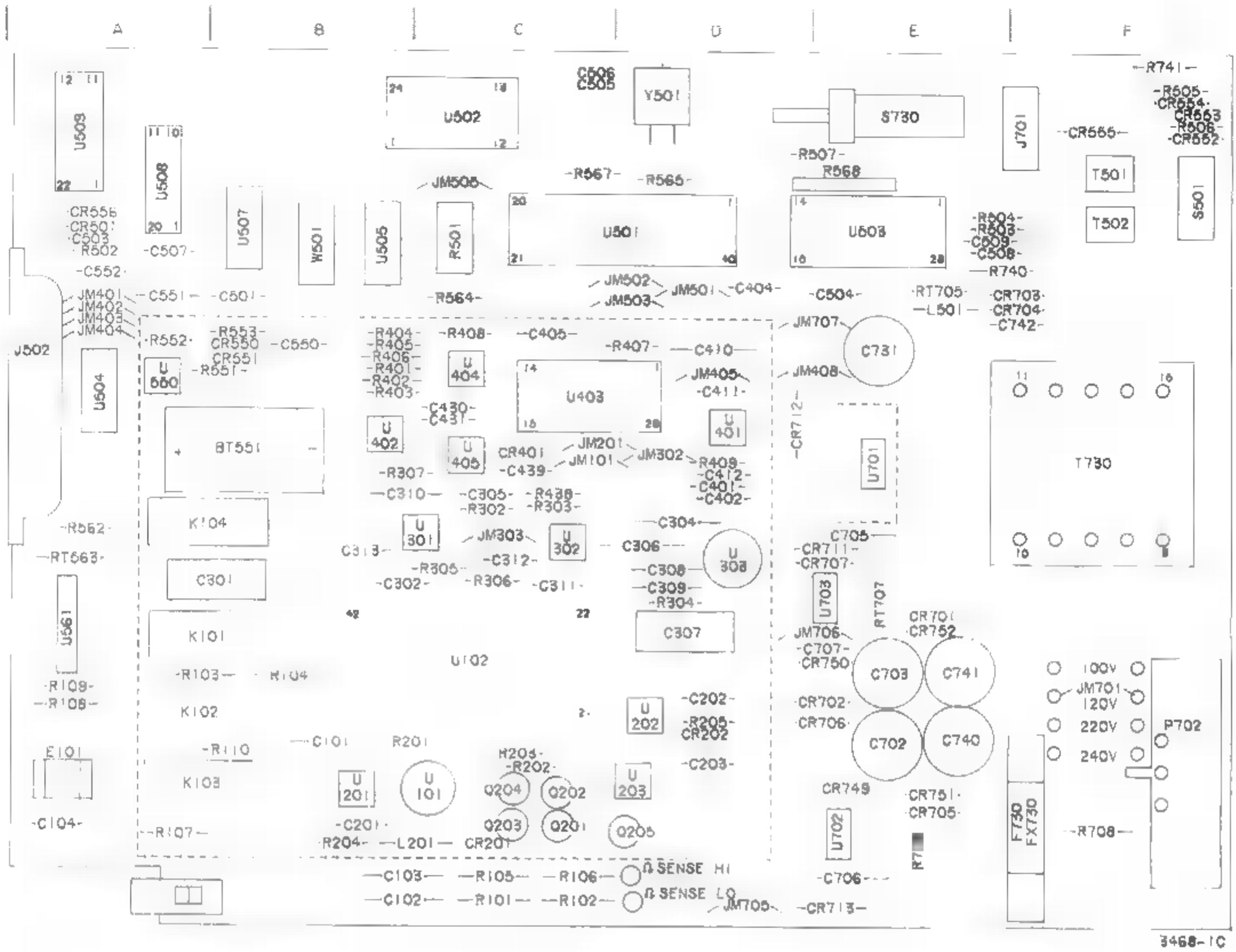


Figure 7-G-3. Input Circuitry and Ohms Current Source



A1

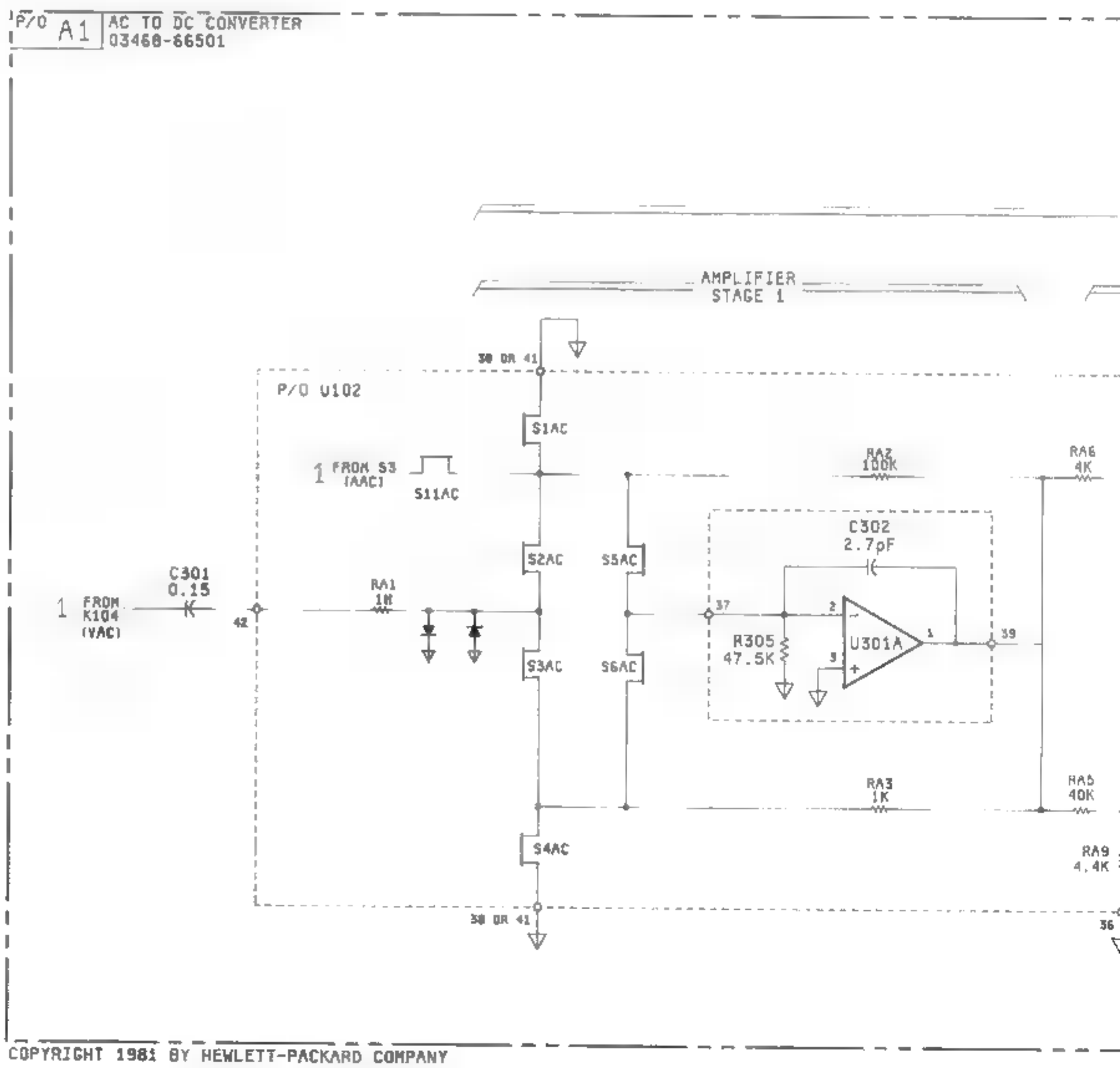
·hp· Part Number 03468-66501

Component	Col.
C301	A,B
C302	B
C304	D
C305	C
C306	D
C307	D
C308	D

Component	Col.
C309	D
C310	B,C
C311	C
C312	C
C313	B
JM302	D

Component	Col.
JM303	C
R302	C
R303	C
R304	D
R305	C
R306	C

Component	Col.
R307	B,C
U102	B,C
U301	B,C
U302	C
U303	D


P/O A1
AC TO DC CONVERTER
03460-66501
AMPLIFIER
STAGE 1
P/O U102
30 OR 41
S1AC
1 FROM S3
(AAC)
S11AC
S2AC
S5AC
S3AC
S6AC
S4AC
C301
0.15
1 FROM
K104
(VAC)
42
RA1
1M
RA2
100K
RA6
4K
C302
2.7pF
37
R305
47.5K
U301A
39
RA3
1K
RA5
40K
RA9
4.4K
36
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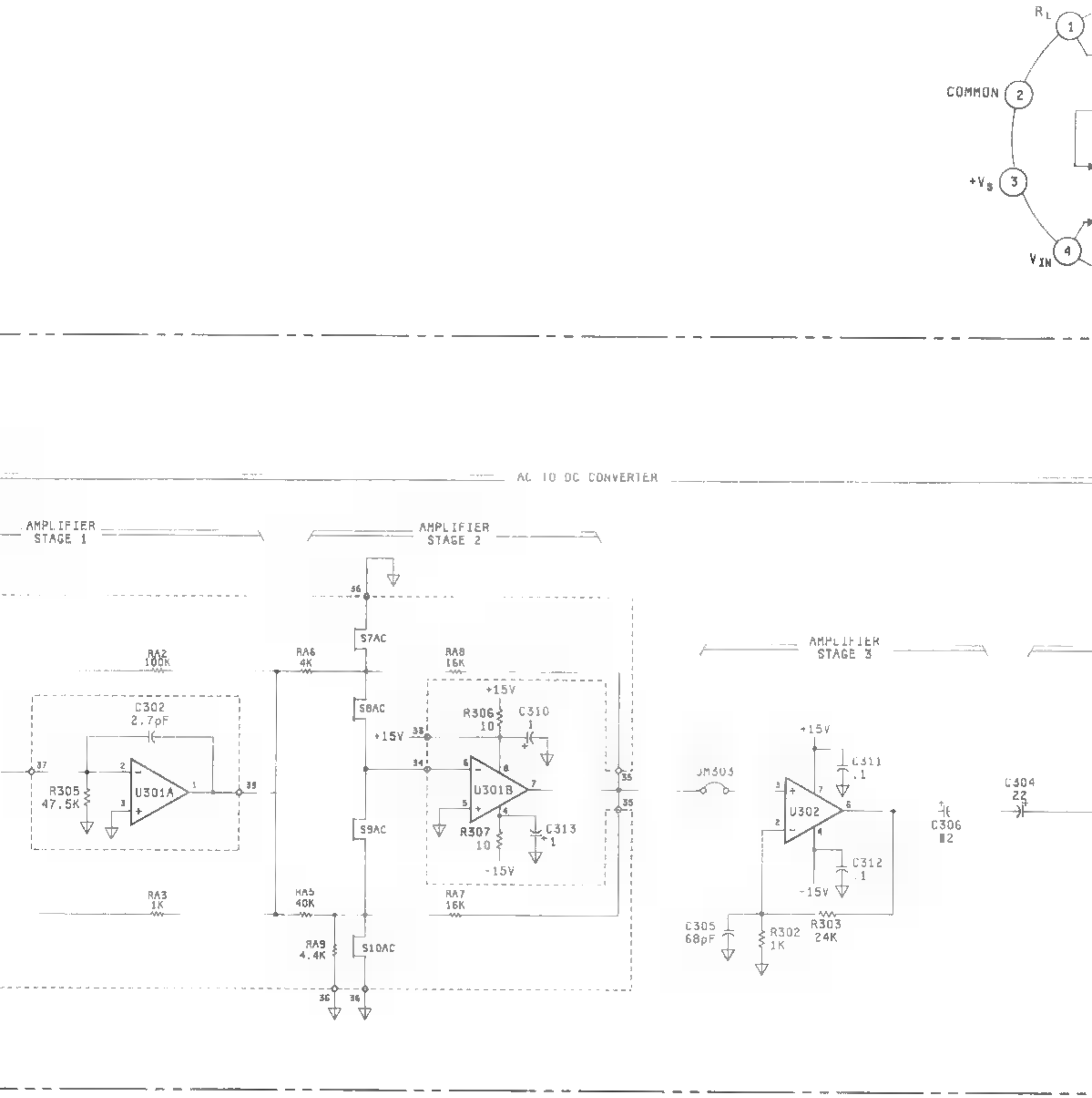

R L
1
COMMON
2
+V S
3
V IN
4
AC TO DC CONVERTER
AMPLIFIER STAGE 1
AMPLIFIER STAGE 2
AMPLIFIER STAGE 3
56
S7AC
S8AC
S9AC
S10AC
RA2 100K
RA6 4K
RA8 16K
C302 2.7pF
R305 47.5K
U301A
+15V
33
34
35
37
39
36
R306 10
C310 1
U301B
R307 10
C313 1
-15V
RA3 1K
RA5 40K
RA7 16K
RA9 4.4K
JM303
U302
C311 .1
C312 .1
C306 ■2
C304 22
C305 68pF
R302 1K
R303 24K

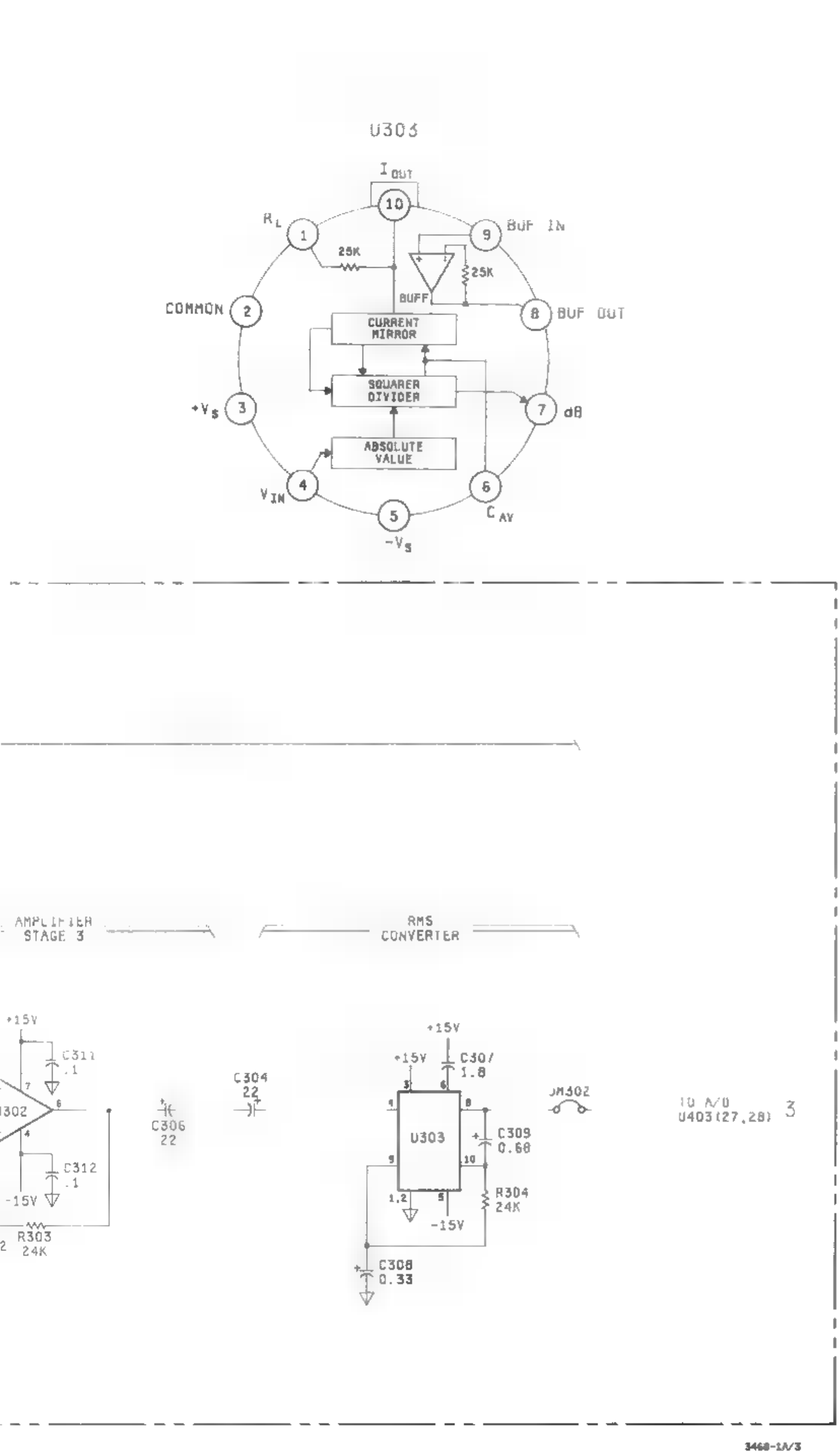
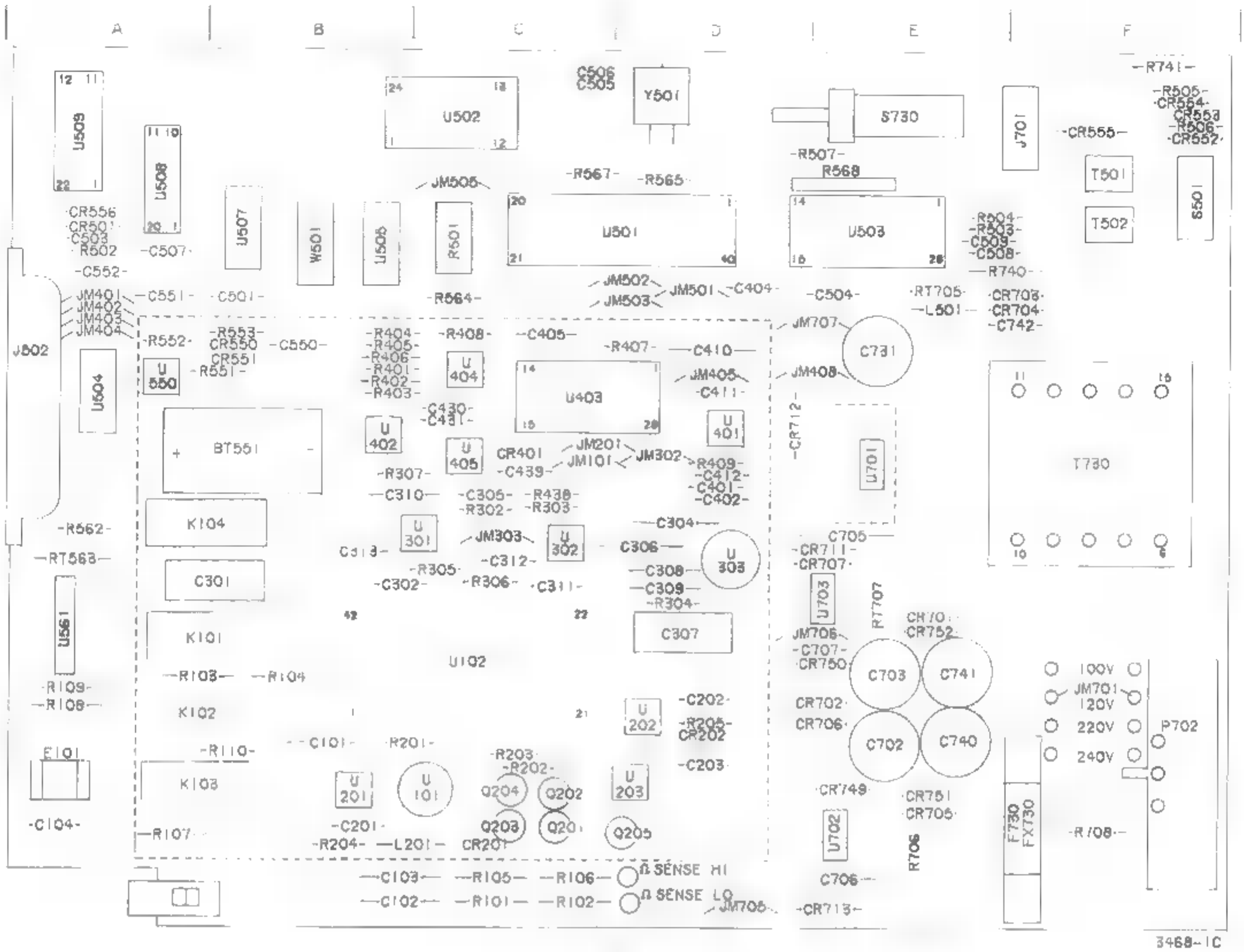


Figure 7-G-4. AC to DC Converter



A1

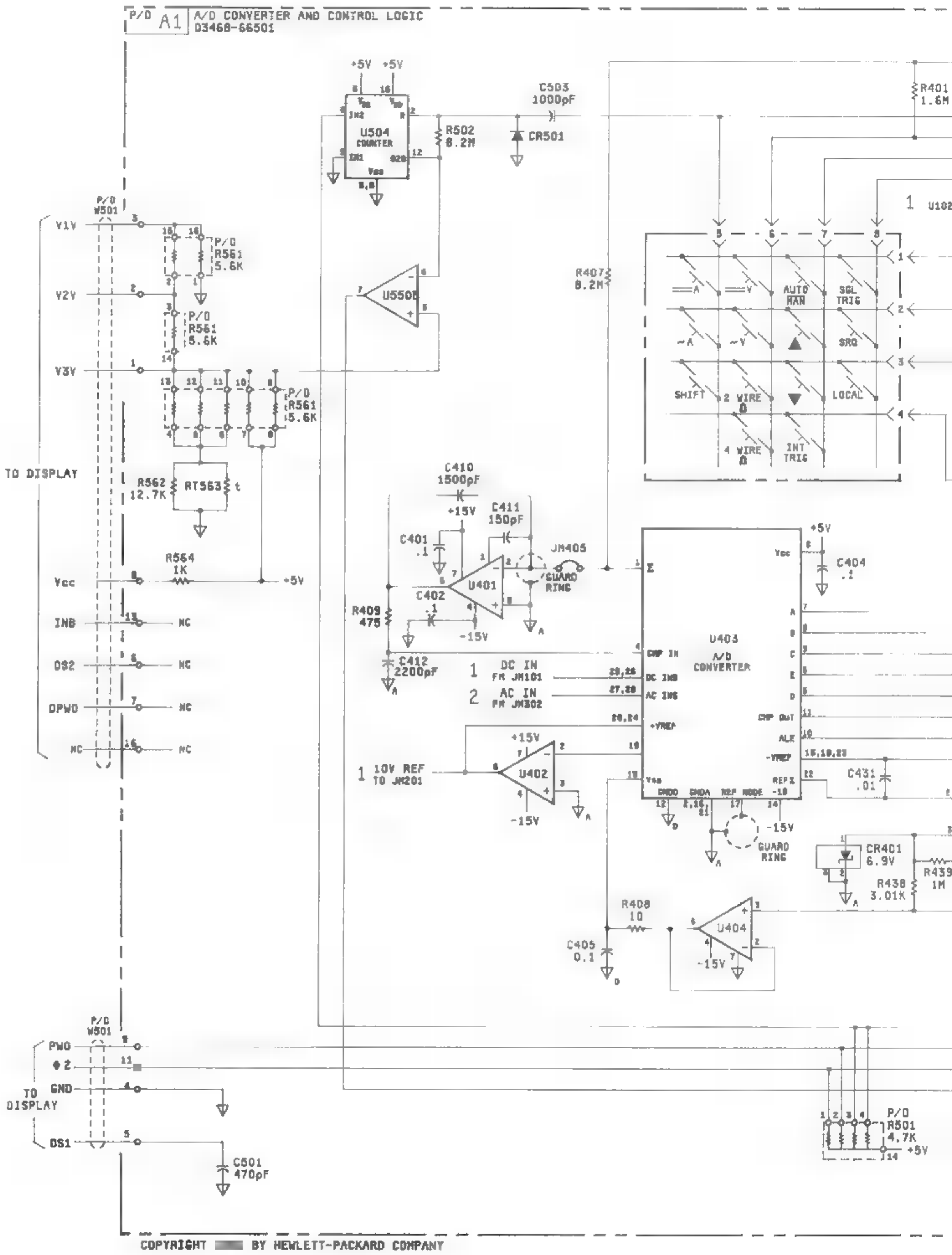
-hp- Part Number 03468-66501

Component	Col.
BT551	A,B
C401	D
C402	D
C404	D
C405	C
C410	D
C411	D
C412	D
C430	C
C431	C
C501	B
C503	A
C504	D,E
C505	C
C506	C
C507	A
C508	E
C509	E
C551	A
C552	A
CR401	C

Component	Col.
CR501	A
CR550	A,B
CR551	A,B
CR552	F
CR553	F
CR554	F
CR555	F
CR556	A
JM401	A
JM402	A
JM403	A
JM404	A
JM405	D
JM501	D
JM502	C,D
JM503	C,D
JM505	C
L501	E
R401	B
R402	B

Component	Col.
R403	B
R404	B
R405	B
R406	B
R407	C,D
R408	C
R409	D
R438	D
R439	C
R501	C
R502	A
R503	E
R504	■
R507	D,E
R551	A,B
R552	A
R553	■
R561	A
R562	A
R564	C
R565	D
R567	C
R568	D,E

Component	Col.
RT563	A
S501	F
T501	F
T502	F
U401	D
U402	B
U403	C,D
U404	C
U405	C
U501	C,D
U502	B,C
U503	D,E
U504	A
U505	B
U507	■
U508	A
U509	A
U550	A
Y501	D



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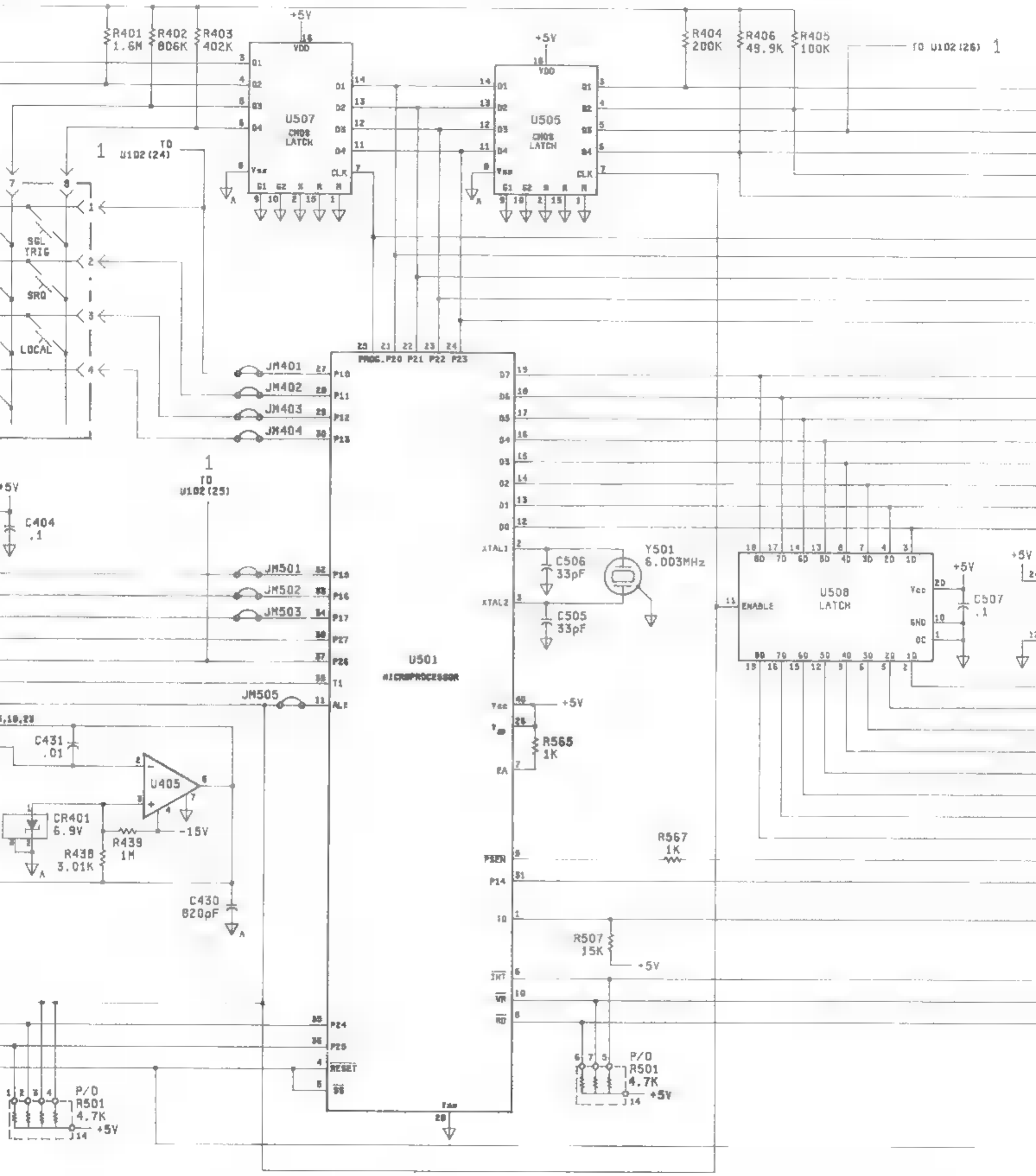
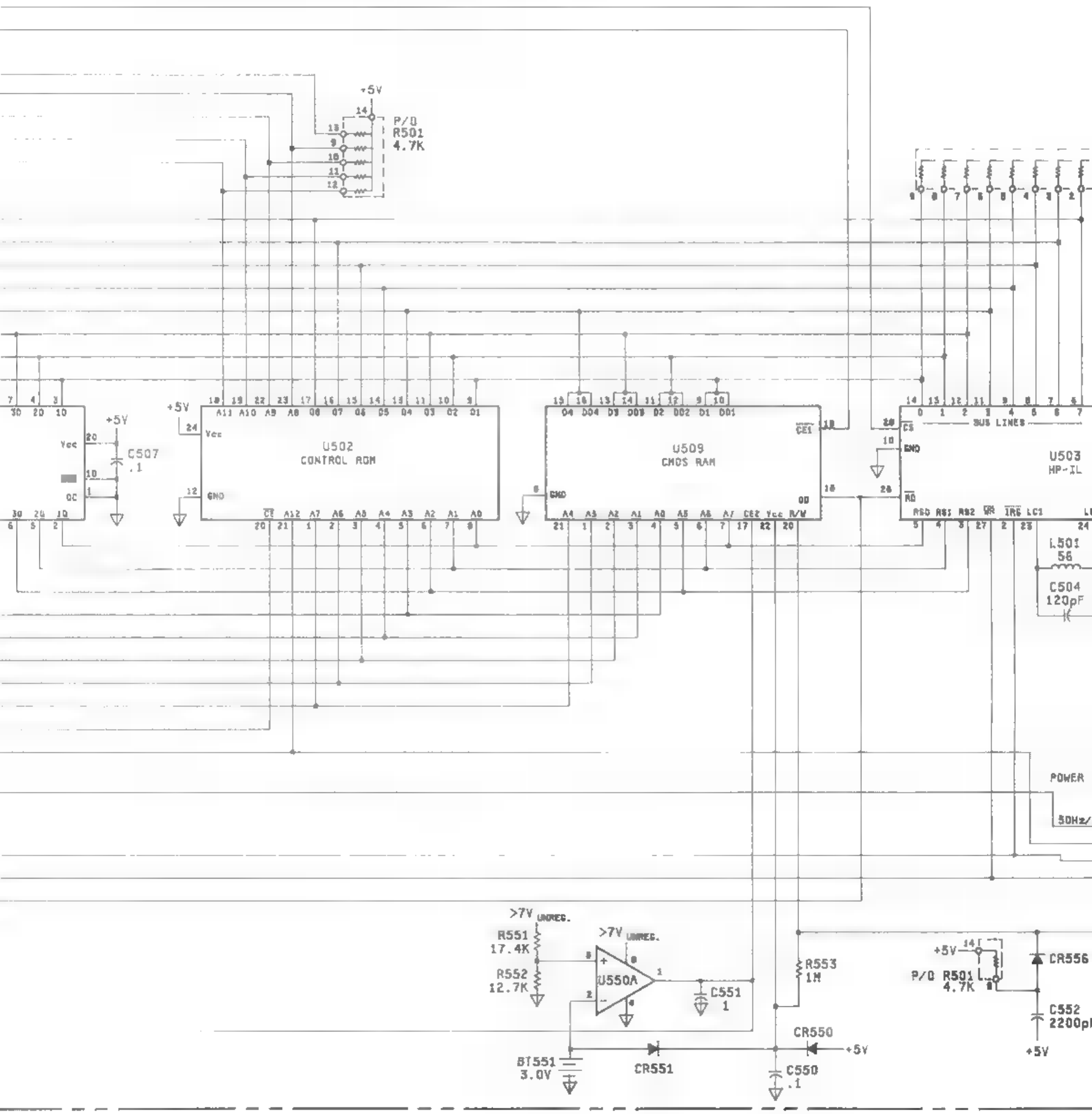

R401 1.6M
R402 806K
R403 402K
R404 200K
R406 49.9K
R405 100K
+5V
U507 CMOS LATCH
U505 CMOS LATCH
TO U102(26)
TO U102(24)
TO U102(25)
SGL TRIG
SRQ
LOCAL
JM401
JM402
JM403
JM404
JM501
JM502
JM503
JM505
C404 .1
C431 .01
U405
CR401 6.9V
R439 1M
R438 3.01K
-15V
C430 820pF
U501 MICROPROCESSOR
XTAL1
XTAL2
C506 33pF
C505 33pF
Y501 6.003MHz
R565 1K
R567 1K
R507 15K
U508 LATCH
ENABLE
C507 .1
P/O R501 4.7K
J14


+5V
P/O
R501
4.7K
U502
CONTROL ROM
U509
CMOS RAM
U503
HP-IL
BUS LINES
C507
.1
L501
56
C504
120pF
POWER
50Hz/
>7V UNREG.
R551
17.4K
R552
12.7K
U550A
C551
1
R553
1M
CR550
CR551
BT551
3.0V
C550
.1
CR556
C552
2200pF

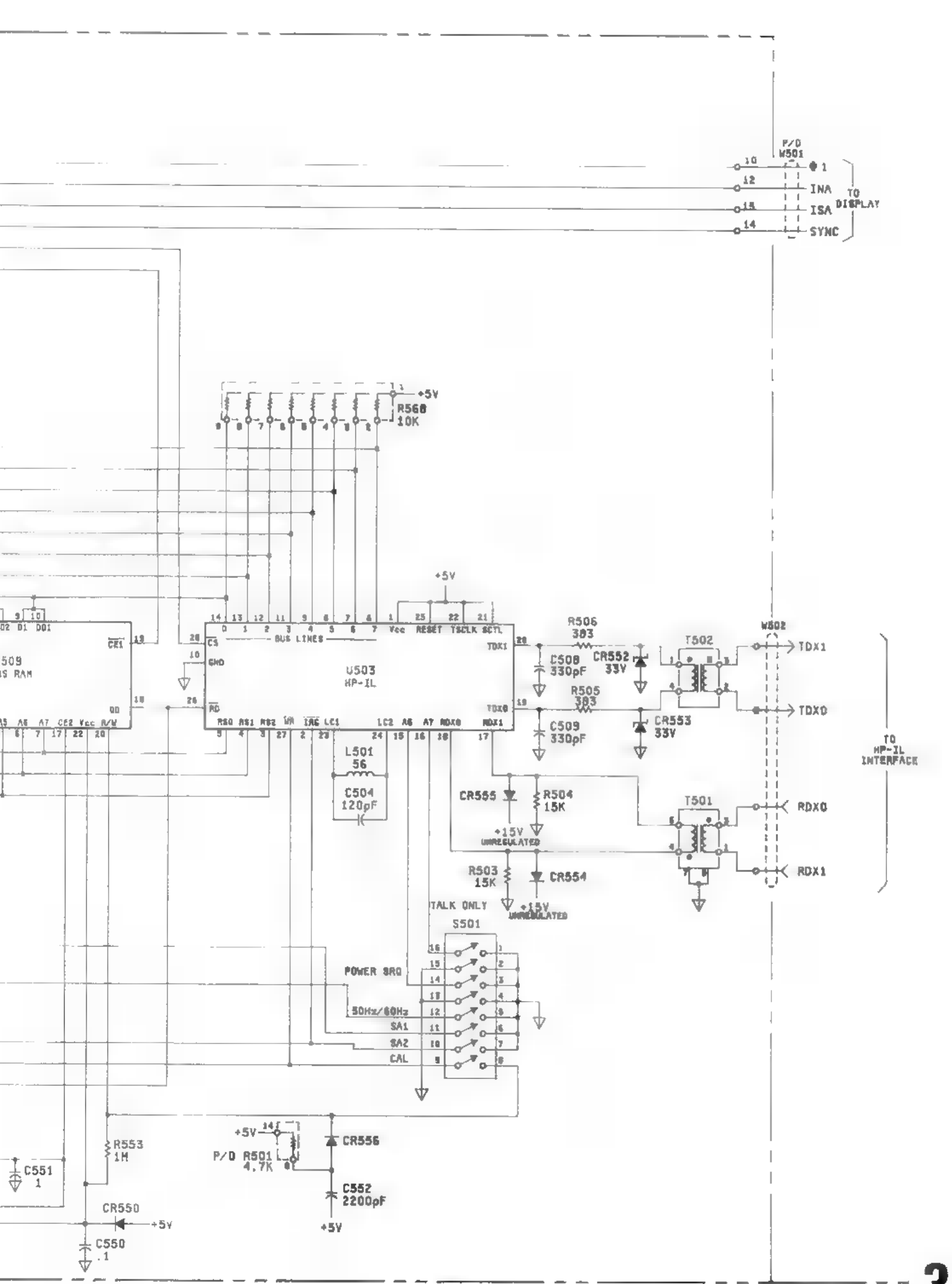
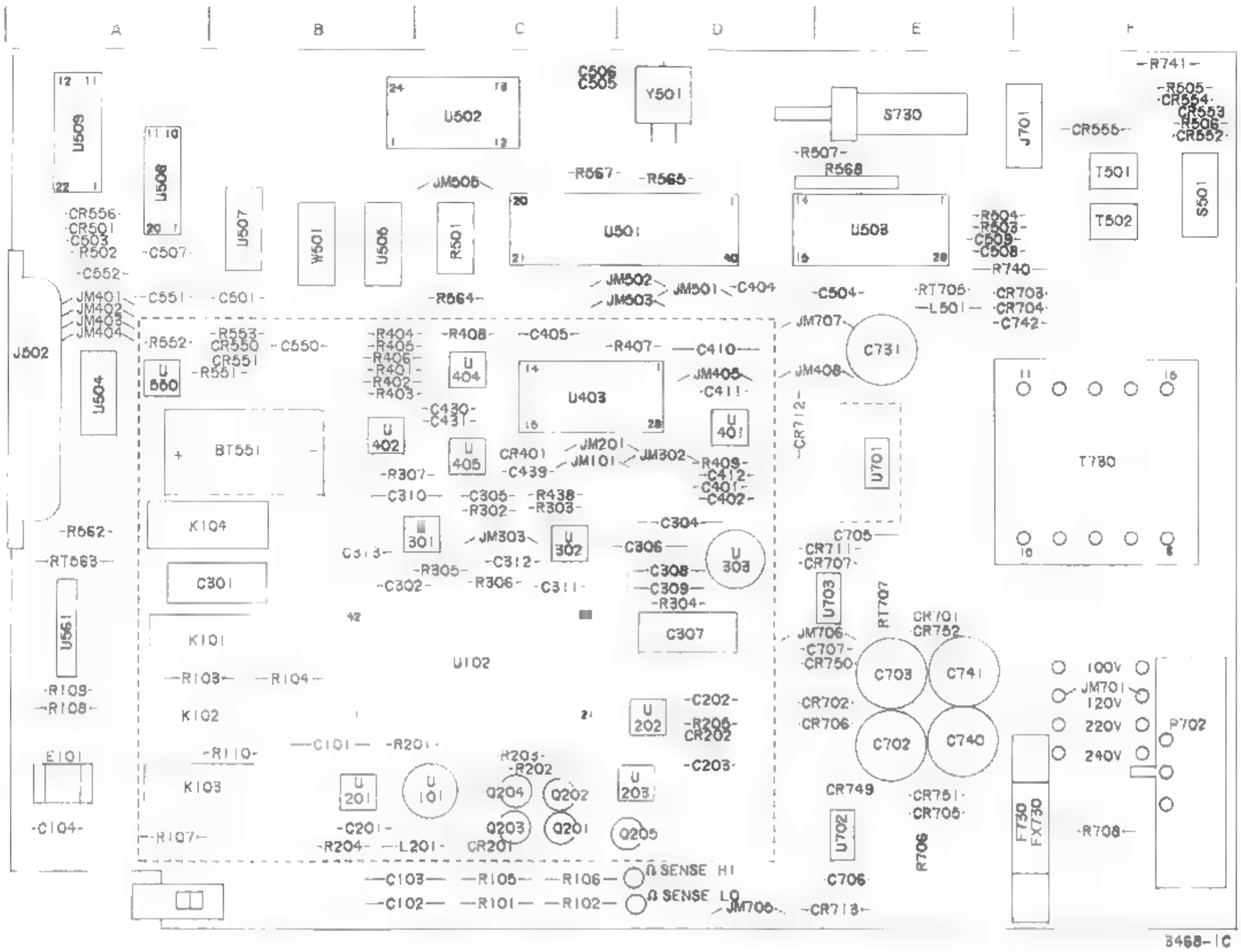


Figure 7-G-5. A/D Converter and Control Logic

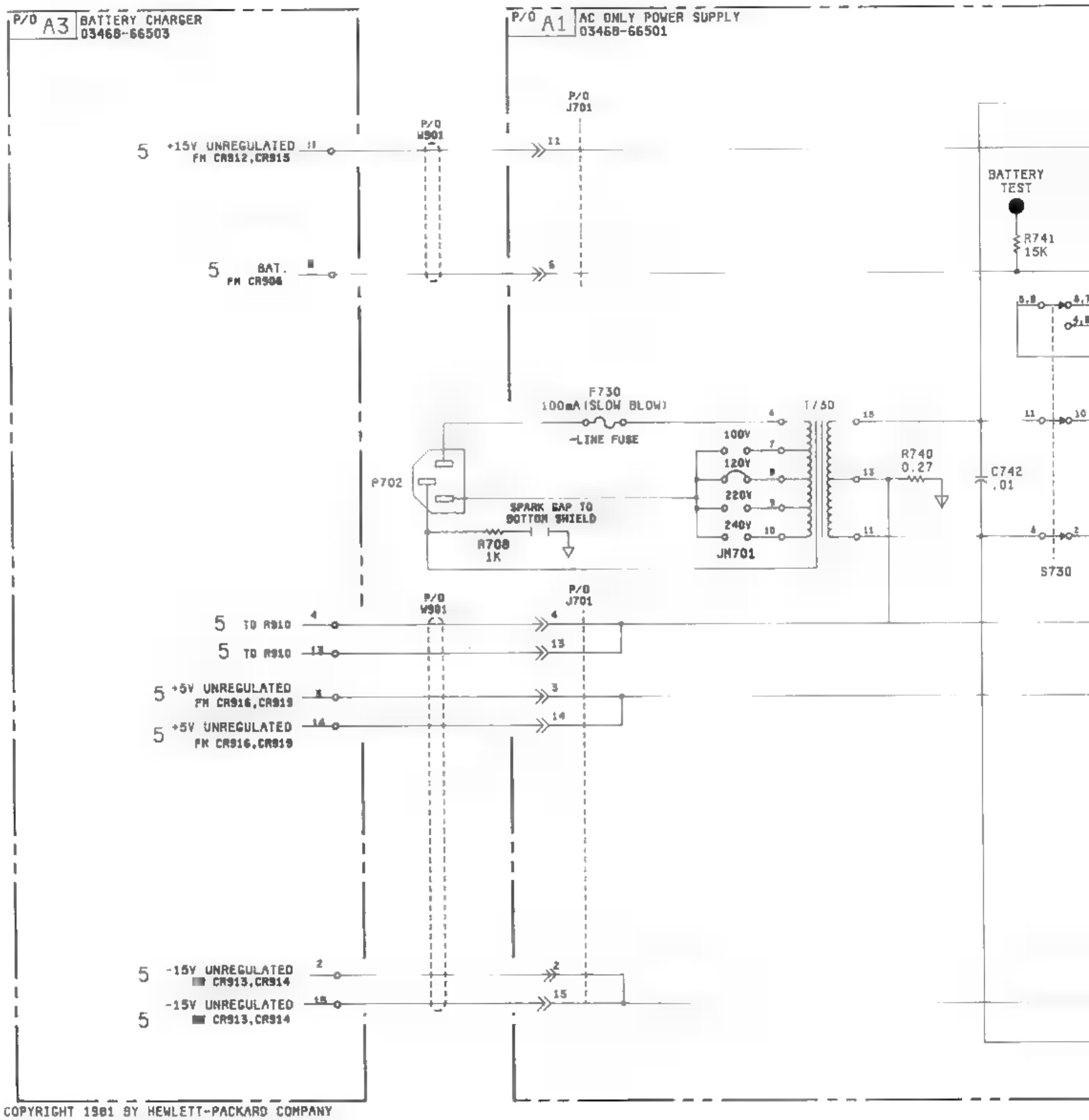


A1

-hp- Part Number 03468-66501

COMPONENT LOCATOR TABLE FOR SCHEMATIC 4 (POWER SUPPLY)

Component	Col.	Component	Col.	Component	Col.	Component	Col.
C702	E	CR703	E,F	F730	E,F	RT705	E
C703	E,F	CR704	E,F			RT706	E
C705	[illegible]	CR705	E,	J701	E,F	RT707	E
C706	E	CR706	D,E				
C707	D,E	CR707	D,E	JM701	F	S730	D,E
C731	E	CR711	D,E	JM705	D		
C740	E	CR712	D	JM706	D,E	T730	E,F
C741	E	CR713	D,E	JM707	D,E		
C742	E,F	CR749	E	JM708	D,E	U701	E
C750	D,E	CR750	D,E			U702	D,E
		CR751	E	R708	F	U703	D,E
CR701	E	CR752	E	R740	E		
CR702	D,E			R741	F		



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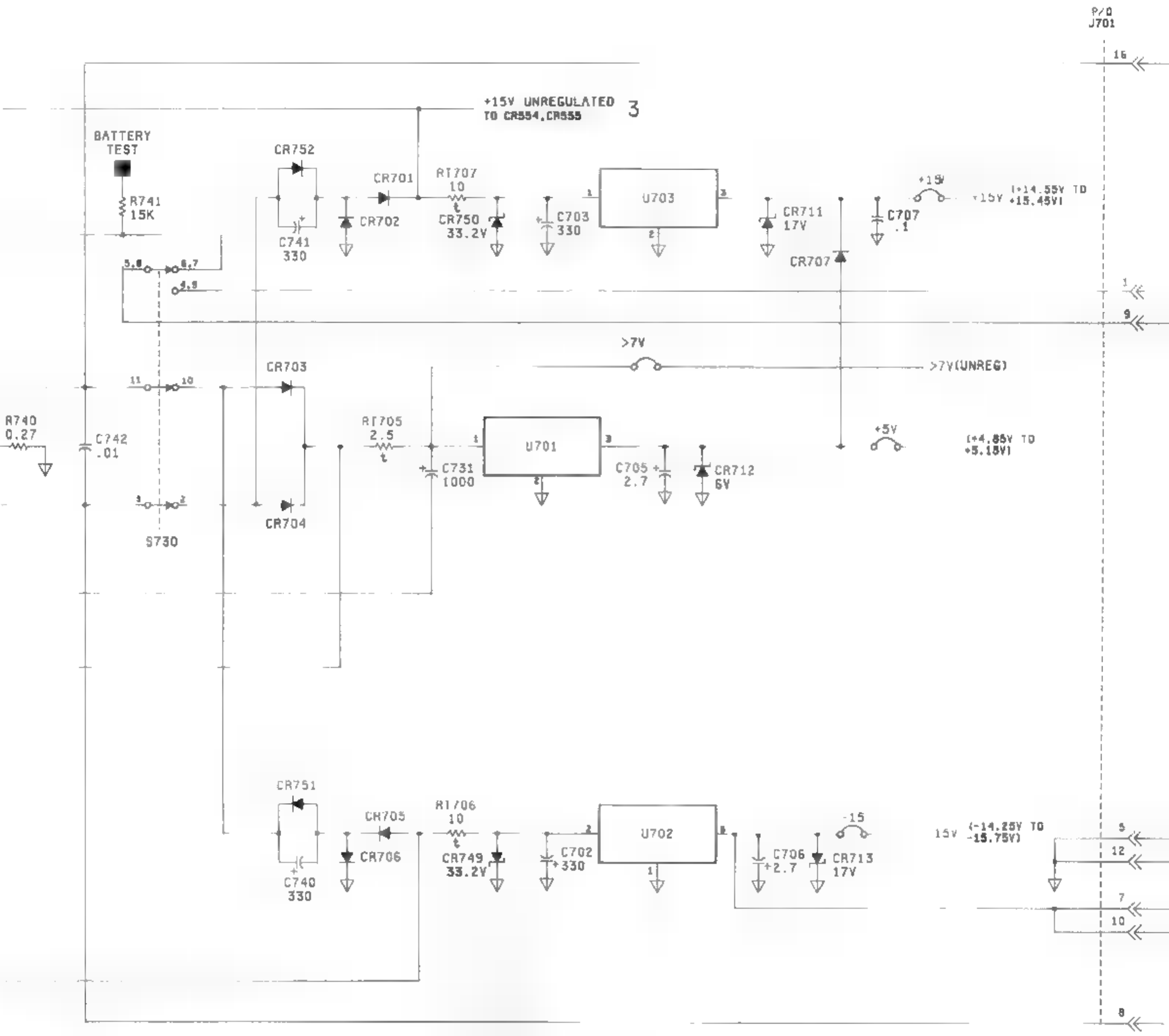
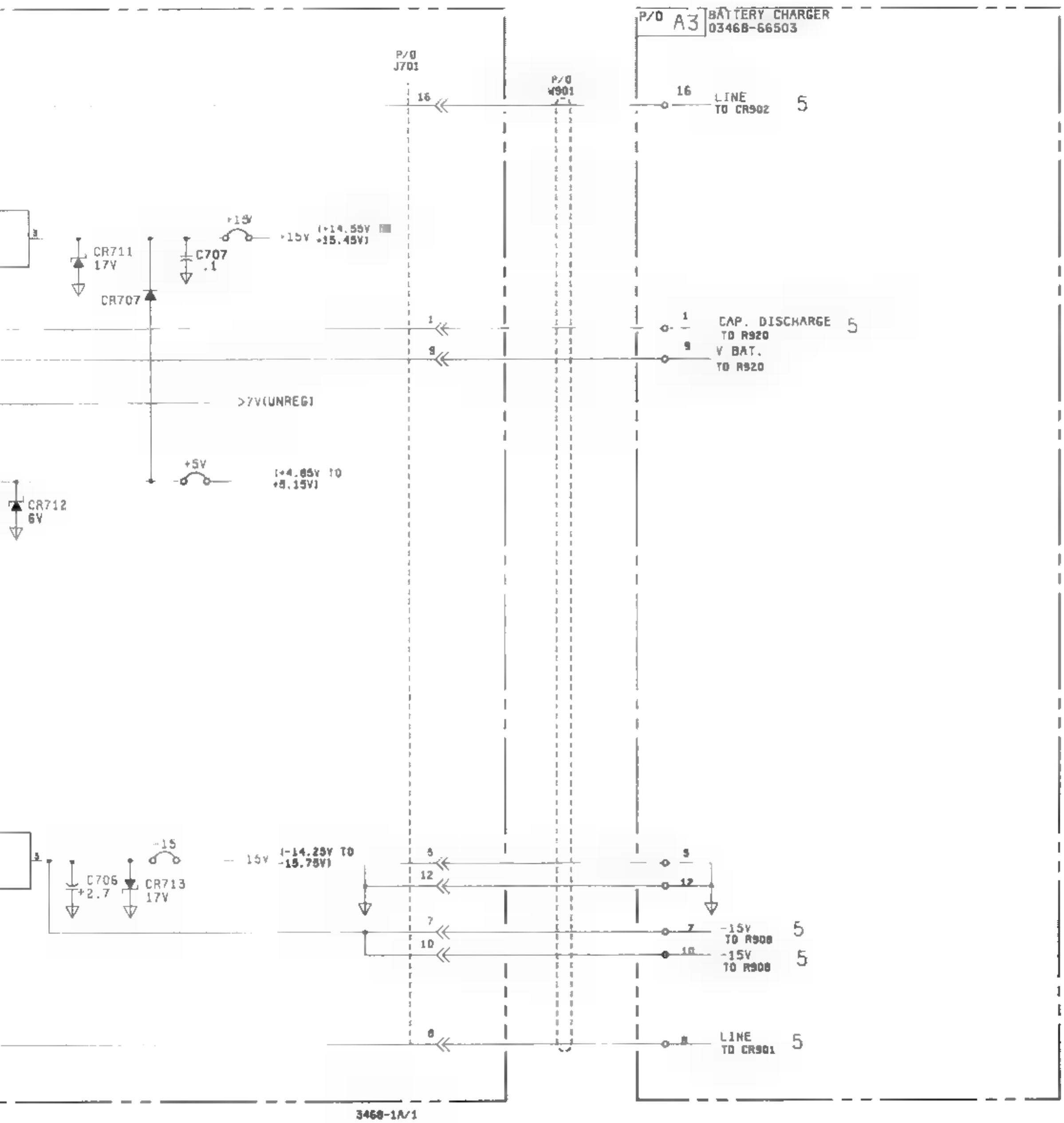
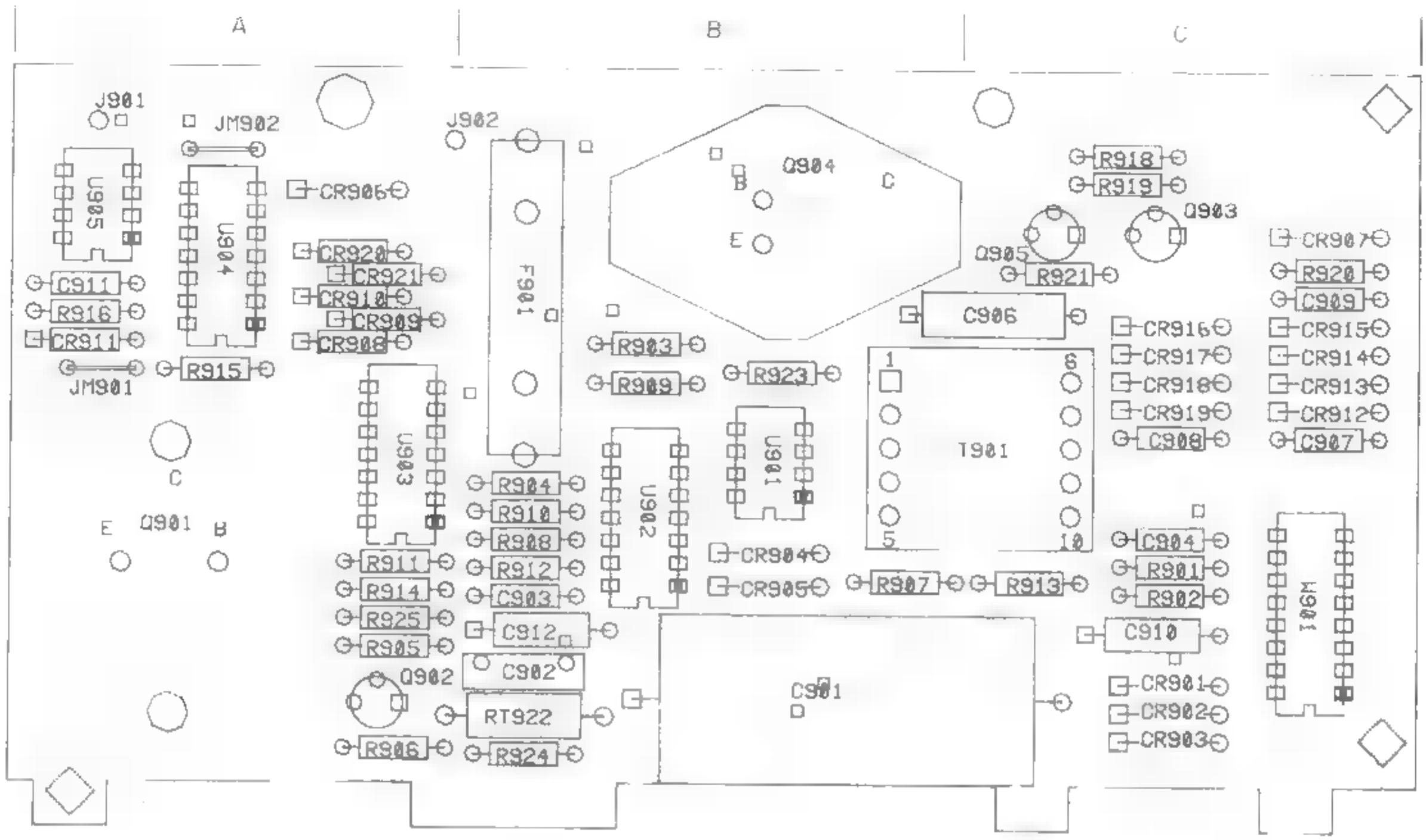

P/O
J701
16
+15V UNREGULATED
TO CR554,CR555
3
BATTERY
TEST
R741
15K
CR752
C741
330
CR701
CR702
RT707
10
CR750
33.2V
C703
330
U703
CR711
17V
CR707
C707
.1
+15
+15V
(+14.55V TO
+15.45V)
1
9
>7V
>7V(UNREG)
CR703
CR704
R740
0.27
C742
.01
S730
RT705
2.5
C731
1000
U701
C705
2.7
CR712
6V
+5V
(+4.85V TO
+5.15V)
CR751
C740
330
CR705
CR706
RT706
10
CR749
33.2V
C702
330
U702
C706
2.7
CR713
17V
-15
15V
(-14.25V TO
-15.75V)
5
12
7
10
8

3468-1A/1



4

Figure 7-G-6. Power Supplies
7-G-9/7-G-10



A3

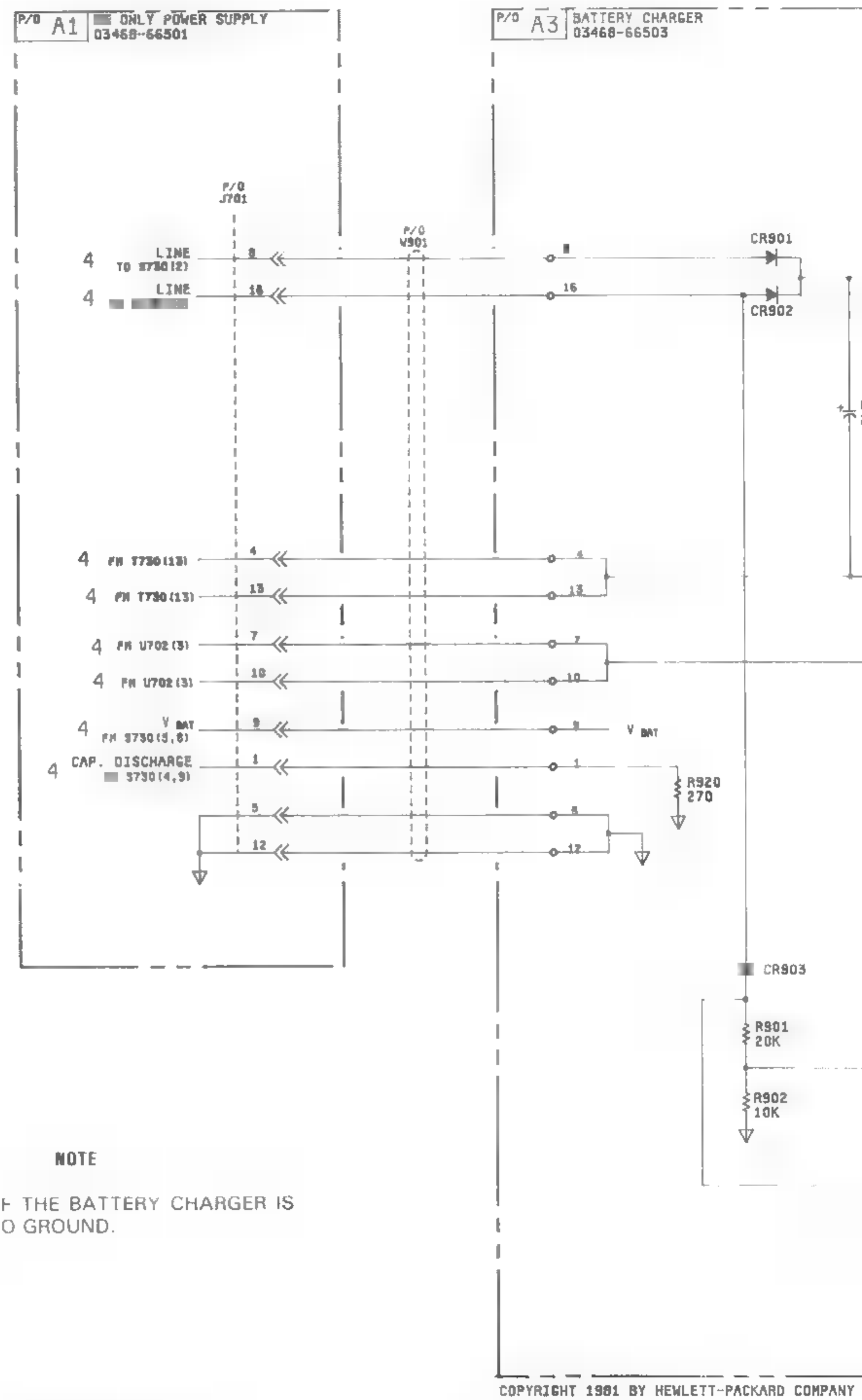
-hp- Part Number 03468 66503

Component	Col.
C901	B,C
C902	B
C903	■
C904	C
C906	B,C
C907	C
C908	C
C909	C
C910	C
C911	A
C912	B
CR901	C
CR902	C
CR903	C
CR904	B
CR905	■
CR906	A
CR907	C
CR908	A
CR909	A

Component	Col.
CR910	A
CR911	A
CR912	C
CR913	C
CR914	C
CR915	C
CR916	C
CR917	C
CR918	C
CR919	C
CR920	A
CR921	A
F901	B
J901	A
J902	A,B
JM901	A
JM902	A

Component	Col.
Q901	A
Q902	A
Q903	C
Q904	B
Q905	C
R923	B
R901	C
R902	C
R903	B
R904	B
R905	A
R906	A
R907	■
R908	■
R909	B
R910	B
R911	A
R912	■
R913	C
R914	A
R915	A

Component	Col.
R916	A
R918	C
R919	C
R920	C
R921	C
R924	B
R925	A
RT922	B
T901	B,C
U901	B
U902	B
U903	A
U904	A
U905	A
W901	C



NOTE

THE SHIELD OF THE BATTERY CHARGER IS CONNECTED TO GROUND.

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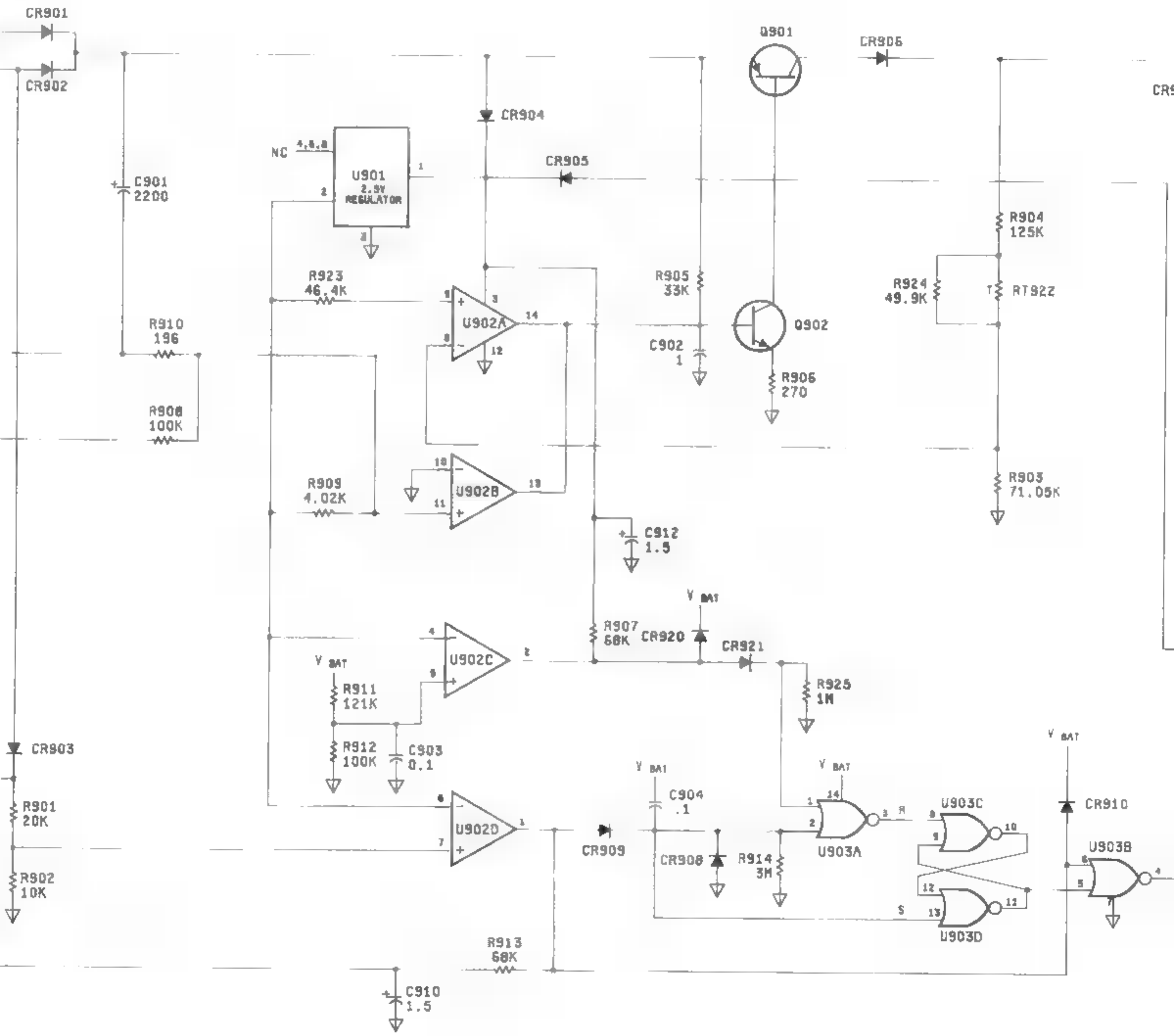
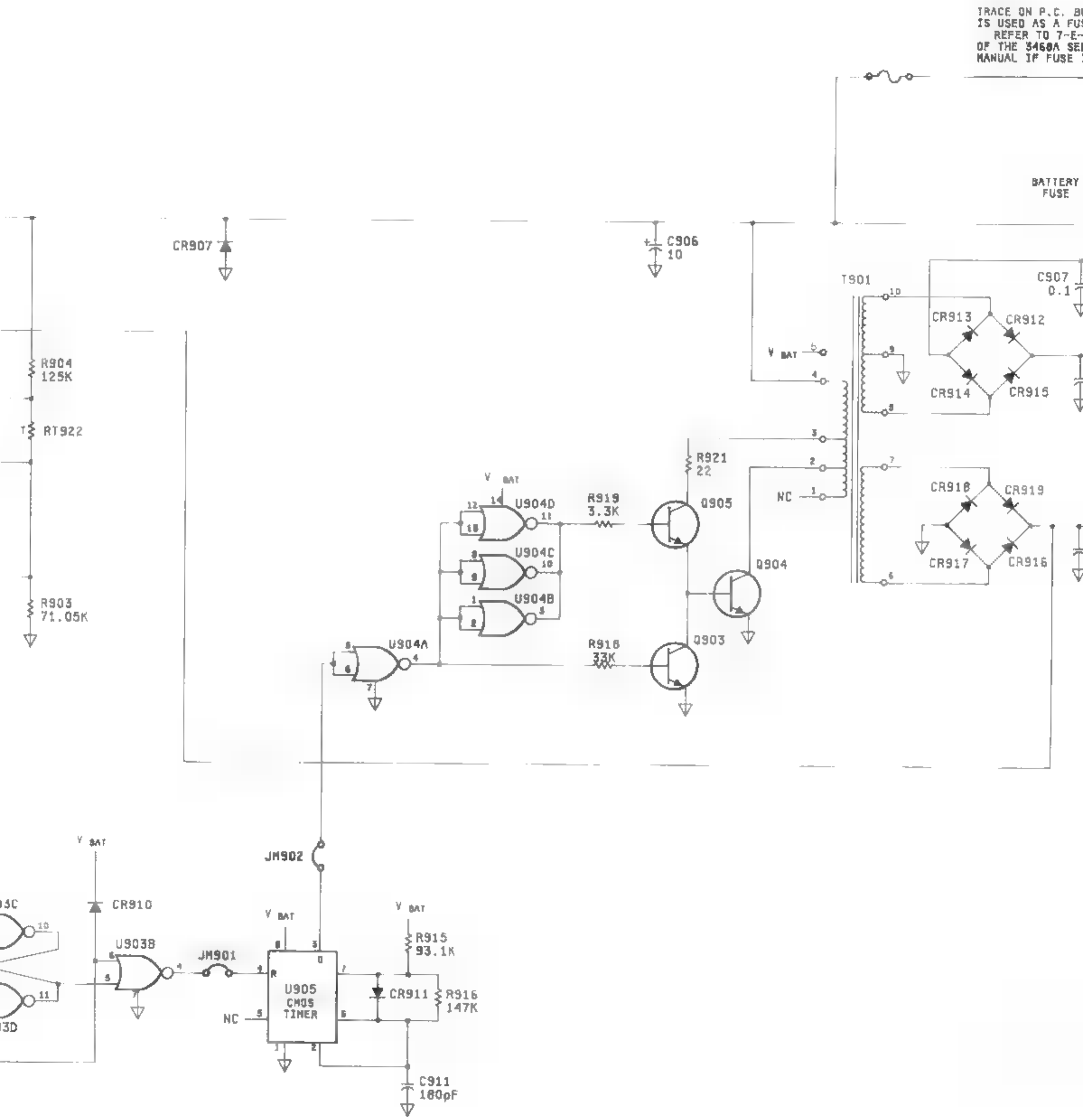

CR901
CR902
C901
2200
R910
196
R908
100K
NC
U901
2.5V
REGULATOR
R923
46.4K
R909
4.02K
CR904
CR905
U902A
U902B
C912
1.5
Q901
CR906
R905
33K
C902
1
Q902
R906
270
R904
125K
R924
49.9K
RT92Z
R903
71.05K
V BAT
R907
68K
CR920
CR921
R925
1M
U902C
R911
121K
R912
100K
C903
0.1
U902D
CR903
R901
20K
R902
10K
CR909
C904
.1
CR908
R914
3M
U903A
U903C
U903D
CR910
U903B
R913
68K
C910
1.5


TRACE ON P.C. BO
IS USED AS A FUS
REFER TO 7-E-
OF THE 3460A SE
MANUAL IF FUSE
BATTERY
FUSE
CR907
C906
10
T901
C907
0.1
CR913
CR912
CR914
CR915
V BAT
R904
125K
RT922
R903
71.05K
R921
22
NC
CR918
CR919
CR917
CR916
V BAT
U904D
R919
3.3K
Q905
U904C
Q904
U904B
U904A
R918
33K
Q903
JM902
V BAT
CR910
U903C
U903B
JM901
V BAT
V BAT
R915
93.1K
U905
CMOS
TIMER
CR911
R916
147K
NC
U903D
C911
180pF

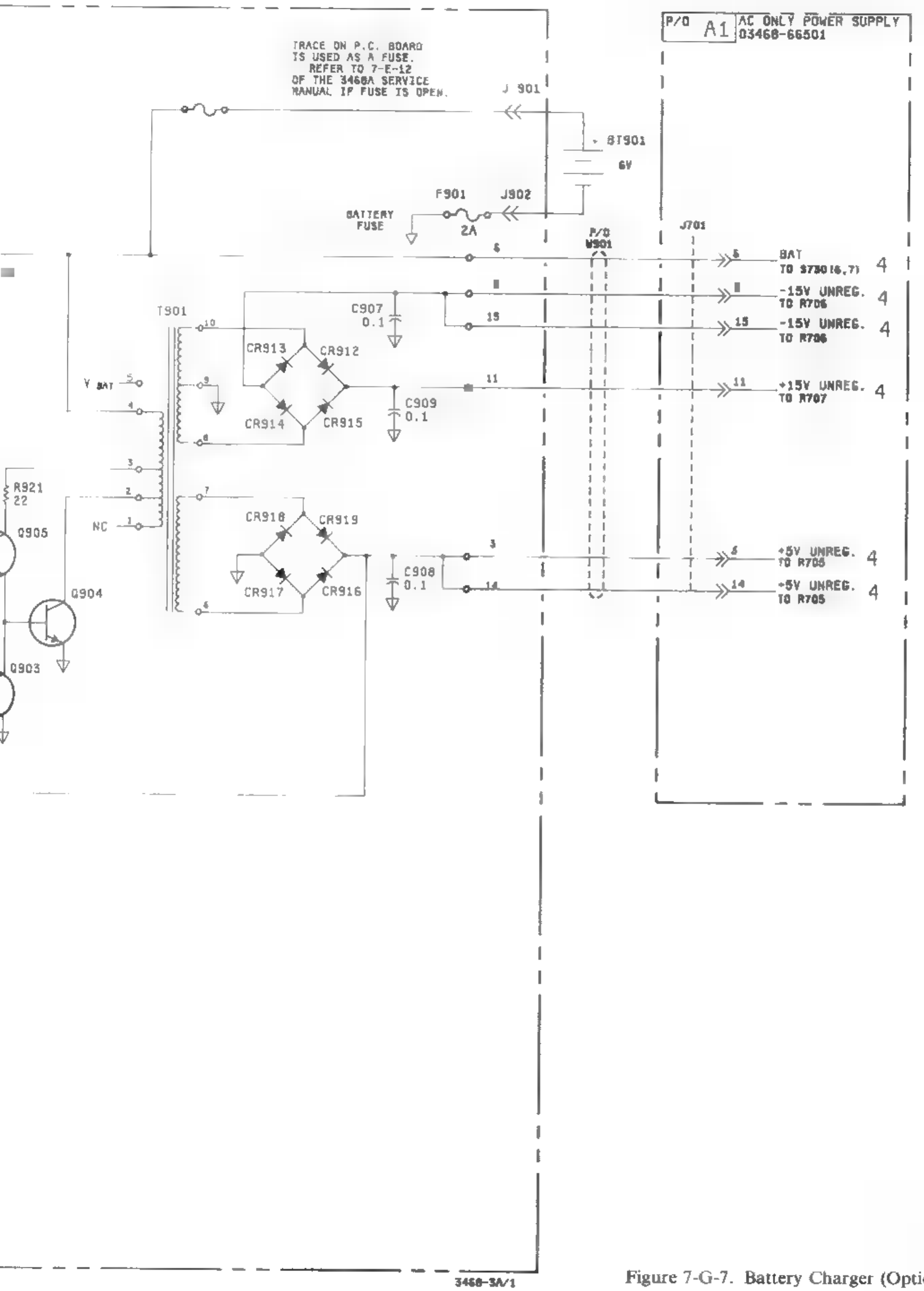


Figure 7-G-7. Battery Charger (Option 001)

Appendix A

A-1. Introduction

A-2. Hewlett-Packard Interface Loop (HP-IL) is a two wire interface that permits communication from one device or instrument to another. As the name implies, devices are connected in a serial loop structure. Data or information, in the form of digital messages, travels from one device to the next around the loop. The following discussion is controller independent but, where appropriate, is dependent on the 3468A.

A-3. General HP-IL Description

A-4. The interface loop consists of a calculator/controller and up to 30 peripheral devices such as the 3468A, printer/plotters, etc. Maximum cable length from one device to the next should not exceed 10 meters to maintain noise immunity. Information is transferred from one device to the next around the loop. If the information is not intended for a particular device (see paragraph on addressing), the device merely passes the information on to the next device in the loop. When the information reaches the intended device, the device responds as directed by the information. In this way, the calculator/controller can send information to and receive information from selected devices in the loop according to the devices capabilities.

A-5. Functional Overview

A-6. Each device in the loop may possess one or more of the three basic device capabilities: Controller, Talker, or Listener. The controller, as the name implies, has the responsibility to control loop activity. The -hp- Model 41C/41CV handheld calculator and the -hp- Model 85 desktop computer are examples of devices which can be used as controllers. They must, of course, be equipped with the proper interface module. Controllers transmit all commands to other devices in the loop and have Talker and Listener capabilities. The 3468A cannot serve as a controller. Only one device in the loop may serve as ■ controller.

A-7. Talkers are devices that have the ability to send data or information (but not commands) through the loop. Note that a talker will not actually send its data or information until told to do so by the controller. The 3468A has Talker capabilities. When the 3468A is talking on the loop its TLK annunciator will turn on. In special situations, one device may be classified as a Talk-only device and sends information to Listen-only devices. Such ■ system would not have a controller. For example, the 3468A can be configured for Talk-only mode and send measurement results to a printer.

A-8. Listeners are devices with the capability to receive information over the loop. When the 3468A is "listening", its LSTN annunciator turns on. Listeners must remain inactive until instructed by the controller to receive the information.

A-9. Addressing

A-10. Each device in the loop is assigned an address by the controller. The assigned address will probably be different than the factory preset address. The 3468A, for example, has a preset address of 22. If the 3468A is the only device in the loop with the controller, the controller will assign it an address of "1". The address permits the controller to specify or select a particular device in the loop when sending commands. Addresses are assigned to devices sequentially around the loop in the direction of information flow. The first device after the controller is assigned an address of "1". The second device is assigned the address "2", and so on around the loop.

A-11. HP-IL System Terms

A-12. The following paragraphs define the terms and concepts used to describe HP-IL system operations.

a. **Address:** Each device in the loop is assigned an address by the controller. The address is used to specify which device in the loop will receive information or send information.

b. **Byte:** A byte is a unit of information consisting of 8 binary digits called bits.

c. **Device:** Any instrument or unit that is HP-IL compatible is called a device.

d. **Device Dependent:** An action a device performs in response to information sent through the loop. The action is characteristic of a particular instrument and will probably vary from device to device.

e. **Frame:** Messages are sent through the loop as a sequence of eleven bits called ■ message "frame".

f. **Polling:** Polling is ■ process typically used by a controller to locate ■ device that has requested service

from the controller. There are two types of polling, Serial Poll and Parallel Poll:

1. **Serial Poll.** When the controller executes a serial poll, the addressed device sends one byte of operational information called a status byte. If more than one device in the loop is capable of requesting service, each device in the loop must be serial polled until the device that requested service is located.

2. **Parallel Poll.** This method obtains a status bit from eight devices in the loop. The 3468A does not respond to a parallel poll.

A-13. Messages

A-14. Every message sent through the loop is sent as a sequence of eleven bits called a message frame. Commands, such as Listen, are made up of one or more message frames. The first bit in each message frame is a sync bit and is specially coded so that each device can recognize the beginning of a frame. The sync bit and the two following bits are called control bits and are used to determine the classification of the message frame. There are three major classifications of frames: Command, Ready, and Data. The remaining eight bits are the data bits and specify the particular message within the classification.

A-15. Normally only one message is in transit around the loop at any given time. In general, when ■ device sources a message it waits until the message goes completely around the loop and returns before transmitting the next message. This is part of ■ process called loop handshaking and guarantees that talkers and controllers do not send messages faster than other devices can accept them. It also provides an excellent error-checking capability. Each message must pass through each device. When a device receives a message, it does not pass it on to the next device until it is ready to receive the next message. Consequently, when the message returns to the sourcing device, it knows for certain that all devices in the loop have received the message and are ready for the next.

A-16. 3468A Loop Capabilities

A-17. The following table lists the HP-IL functional subsets that the 3468A responds to and uses.

■	The 3468A handshakes as a receiver
D	Handshakes as a driver to the next device
AH	Handshakes as an acceptor
SH1	Handshakes as ■ source
T1,2, 3,5,6	Basic Talker, Send Status, Send Device ID, Talk Only, and unaddressed ■ a Talker when addressed to Listen
TE0	No extended Talker capability
L1,3	Basic Listener and unaddressed to Listen when addressed to Talk
LE0	No extended Listener capability
C0	The 3468A cannot serve as a controller
AA1	Can be autoaddressed by the controller
AE0	No extended addressing capability
AM0	No multiple addressing capability
DC2	The 3468A responds to a Device Clear and Selected Device Clear
DT1	The 3468A responds to a Device Trigger
RL2	Basic Remote, Local, and Local Lockout capability
SR2	Basic Service Request and Asynchronous Service Request capability
PP0	The 3468A does not respond to a parallel Poll
MS1	The 3468A does have a manual Service Request
PD0	The 3468A does not have a power-down capability
DD0	The 3468A does not implement device dependent Talker or Listener commands

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M

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Hewlett-Packard Italiana S.p.A
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CH,CS,E,M,P

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Hewlett-Packard Española S.A.
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